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Validation of Web Based Learning Environment using Instructional Design Model

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Abstract - The growth of Internet, Intranets and the World Wide Web has already had a significant impact on business, commerce, industry, banking, finance, education, entertainment, governmental and even our personal and professional lives. Many legacy information and database systems are being migrated to the Internet and Web environments. In the last few years, we have seen web sites that were initially started as a few Web pages, which grew in size and after a while became unmanageable. Over a period of time, if one wants to make some changes in the information, it will be very difficult or impossible. The real value of Web-based learning is to help students acquire knowledge that enables them to function as an active, self-reflected and collaborative participants in the information society. Changes caused by academic institutions, course content, ethical, legal, and cultural issues need to be considered in the development of Web-based learning (Hadjerrouit, 2006). These factors have made the researcher to explore a disciplined and systematic way to develop a large and maintainable web based information system that must constantly evolve in order to ensure the relevance and completeness of the content on the web. The Web-based learning environment is developed for a course in the Master of Computer Applications (MCA) programme, which is conducted under the curriculum of Anna University.

Keywords: Web engineering, Web-based system development, Web design, Web development, Pedagogy.

I. INTRODUCTION

Web-Based Learning Environment is entirely different from software development because it is embedded in the online environment. And, it should mainly focus on scalability and maintainability, learning theories and examine technical, legal, cultural and social aspects. Web-based systems evolve from static, content-driven applications to dynamic interactive and ever-changing ones. Hence, there is a need to adopt a sound methodology throughout the development process and maintenance. Considering the need and advantages of the Web Based system, the present study titled "**Development and Validation of a Instructional Design Model for Web Based Learning Environment**" has been carried out, in order to develop a systematic process to maintain a large web based information system and also to ensure the relevance, correctness, completeness, self pacing and effective learning of the content available on the web to the students. For the purpose of research study, the course on Computer Graphics and Multimedia Systems of the third semester of MCA programme under Anna University, curriculum has been taken.

II. RATIONALE

Tele-density in India is currently found to be poor (2.6 per hundred) when compared with China or the West. But it is growing in a geometric proportion. Due to this growth, e-learning market is rapidly shifting to m-learning. There is a heavy demand for Computer Applications (Engineering subjects) e-content developments. According to Said Hadjerrouit (2006), the teaching paradigm of e-learning must be shifted from traditional methods to m-learning. Care should be emphasized while designing mobile Based Instructions. Technical/operational aspects of learning objects and their reusability is becoming a challenge - Natasha Boskic (2003). Merrill's (2002) 'First Principles of Instruction' has been proven to be successful when adapted for instructional designs, particularly for problem centric subject contents.

This research work in view of the above, is attempting an m-learning model that would use reusable objects that are of independent entities. This model would thus attempt to use Merrill's portrayals. One of the research objectives is therefore, to propose an effective model for developing e-content **on 'Computer Graphics'**. Both experimental as well as social study research methodologies have been recommended. This research work is question's based and not hypotheses based.The research work limits its scope of study to the subject content of **'Computer Graphics'** that is selected based on interview schedules. A preliminary investigation has resulted into certain issues that are pertaining to e-tutoring of **'Computer Graphics'**. 11 parts of NPTEL modules of Computer Graphics have been taken for the study for comparative study on instructional effectiveness of m-learning. Content analysis has been performed on selected e-contents of **'Computer Graphics'**. The results clearly show that 'information' need not be 'instructive'. Besides, the content analytical results that are documented would be of immense value for further research.While the content analytical results have suggested for modular approach through using reclaiming model of Merrill (2002); the one that adapted unidirectional instructional model for NPTEL would be analyzed. Strategic instructional components for e-content development have been determined using social survey. 18 strategic components have been derived out in the research. These components include issues like: 'time-duration of e-content modules; need for animated graphics; need for independent reusable modules for e-content etc.Based on the content analytical work and the e-content developmental instructional strategies, an instructional model has been proposed. The basic e-content development has adapted standards like SCORM initially. Merrill's 'First Principles of Instructions' (FPI) has been applied to the algorithm and test runs have been carried out for experiments. The model bases the following layers:
Objects layer; Modules meta-file containing essential procedures; sections layer and the main procedures. Sharable Content Object (SCO's) 'Black Box' has been tried out

successfully. The proposed e-content development model has been experimented with 500 respondents (learners). This social survey was administered for validating the proposed model through experiment.

Plethora of e-contents of CSE subjects is available in the www. Most of these e-contents are found to be in the style and form of text books. Besides, no course objectives have been found spelt out for most of these e-contents. It is thus observed and believed that many users of e-contents do not seriously utilize for rigorous learning. They found to be viewing these e-contents for reference only. As seen from several published research works, that learner characteristic is a very important component needed for the design of these kinds of e-contents. Literature also show that e-learning should be objective driven. In that case this should pose some basic questions like what kind of instructional model for e-learning would fit in well for particular learner characteristics. How to validate such instructional models? How to quantify learning abilities in existing e-contents? etc. These cruxes have led to take up this research work. The research is delimited to the subject area of CG. Important and major conclusion such as the need for small, independent reusable modular (objects) approach is validated.

III. RESEARCH METHODOLOGY

One of the aims of this research is to study and to document the levels of competencies (learning abilities) based on ‘First Principles of Instructions’, an Instructional model based on Constructivism and Cognitivism, that are existing in the prescribed instructional materials of NPTEL modules. The research work also aims at building an appropriate model using the cognitive structures of the ‘First Principles of Instructions’ for e-content delivery. The validation of such a model would be achieved through questionnaires and interview schedules. These feedbacks and the descriptive content analysis on the Instructional materials would be subjected to rigorous studies. Prior to these proposed studies, the subject domain as a case study for the research purpose need to be determined. The methodology adapted for this too is based on social survey and interview schedule. The development of e-content for a chosen section is done through experiment using the proposed model. The methodologies and the application is briefed through Table 1.1.

Table 1: Methodology Adopted for Research

S.No	Method	Purpose
1.	Descriptive	Content analysis on existing NPTEL e-Content
2.	Social Survey	Determining Instructional Strategy
3.	Experiment	Design of Model
4.	Social Survey	Validating the Model

3.1 Statistical Analysis

In the general process of analysis of research data, statistical methods have contributed a great deal. Statistical methods have been extensively applied for most types of analyses. The following are some statistical methods of analysis considered for this research. Some of the common statistical parameters used are presented:

- Calculating frequency distribution of items under study
- Calculating measures of central tendency – Mean and weighted average
- Calculating measures of dispersion – Standard deviation
- Graphical presentation of data – Bar charts

Suitable statistical package has been applied (SPSS-16.0) to find out the required results, namely frequency distribution, mean, weighted average and standard deviation. The reliability has been ascertained using the value of Cronbach’s alpha. Number of responses received by the researcher is more than the number of actual samples. Abnormal responses, which caused high deviation of standard and unfilled (blank) responses, were considered unreliable and discarded. Like interpretation of results, the formulations of conclusions and generalizations will be carefully designed.

3.2 Sampling and Actual Samples

Universal sampling for the Instructional materials of the selected area has been adopted. Purposive sampling has been considered for the feedback analyses, as it is known to be representative of the total required data, and known to represent well-matched groups (Sharma (1988)).Delphimethod has been adopted to validate instruction model through social study. The actual samples considered for various studies are presented in Table 1.2.

Table 2: Actual Samples Considered for Various Study

S.No	Samples	Purpose	Validation	Respondents
1	25	Pilot Study	Determination of course for case study	Mixed respondents
2	120	Formal study	Determination of course for case study	Teacher respondents
3	328	Formal study	Determination of course for case study	Student respondents
4	25	Pilot Study	Determination of Instructional Strategies for e-content	Mixed respondents
5	328	Formal study	Determination of Instructional Strategies for e-content	e-content learners
6	124	Formal study	Validation of Instructional Model	e-content learners

3.3 Analytical Methods

David Robertson (1976) created a coding frame for a comparison of modes of party competition between British and American parties. It was developed further in 1979 by the Manifesto Research Group aiming at a comparative content-analytic approach on the policy positions of political parties. This classification scheme was also used to accomplish a comparative analysis between the 1989 and 1994 Brazilian party broadcasts and manifestos as reported by Carvalho (2000). It is also noted that every content analysis should depart from a hypothesis. This is an important statement as this research work has taken ‘Content Analysis’ as an experimental method. Ole Holsti (1969) groups 15 uses of content analysis into three basic categories:

- make inferences about the antecedents of a communication
- describe and make inferences about characteristics of a communication

- make inferences about the effects of a communication.

He also places these uses into the context of the basic communication paradigm. Texts in a single study may also represent a variety of different types of occurrences, such as Palmquist's (1990) study of two composition classes, in which he analyzed student and teacher interviews, writing journals, classroom discussions and lectures, and out-of-class interaction sheets, but more importantly texts books. To conduct a content analysis on any such text, the text is coded or broken down, into manageable categories on a variety of levels--word, word sense, phrase, sentence, or theme--and then examined using one of content analysis' basic methods: conceptual analysis or relational analysis. Questions are generally used for content analysis.

Content analyses, for quantifying the four phases (cognitive structures) of the First Principles of Instruction have been directly or indirectly reported from the following literature studied. Mc Carthy (1996) has emphasized that all the four cognitive structures of First Principles of Instruction are equally important in the whole cycle of a learning activity. She has also argued that they are equally important to learners and the learners must involve completely in all the four phases. Merrill (2002) has also emphasized that any instruction must engage students in all the four levels of performance. But coaching should gradually decrease from problem to problem. He has clarified on the interpretations of the definitions of the four phases: On 'Activation' he stresses: "Many Instructional products jump immediately into the new material without laying a sufficient foundation for the students. 'Activation' is more than merely testing prerequisite knowledge. It should include themes also. A simple recall of information is not effective activation". On 'Demonstration' he stresses: "It should demonstrate 'what is to be learned' rather than just 'informing what is to be learned'". He further adds: "For Concepts use Examples/Non-examples; for Procedures use Demonstration; for Processes use Visualizations; and for Behaviour use Modelling". On 'Application' he points out to the use of media while he says "Media should play an important role for 'Show examples' rather than 'Telling generalities'". On 'Integration' he adds: "Learners can create, invent and explore new ways to use their knowledge. It is a very important component. Media can be limitedly used for it". Merrill (2007) has further elaborated these components into instructional strategies.

On quantification, Lianghuo Fan (2004)has stressed: "Instructional objectives should be quantified in every component of the curriculum, particularly in the instructional materials. They lead to student's abilities such as thinking abilities, judging abilities and reasoning abilities. It helps the teachers to keep in mind how much a topic is more difficult than another topic. This point is important and further strengthens the need for content analysis. On the quantification of different cognitive structures, different opinions are seen from literature. Merrill himself has suggested for having more "Integration" component in e-learning content and less "Application". Nelson (1999) stresses more on 'Application" and less on "Demonstration" for better critical thinking, which involves social interaction skill. Jonassen (1999) on Constructivist learning has stressed on all the four cognitive structures to be of importance. But real world 'Problem' is the most important starting point, he adds. Again the problem should be interesting, relevant and engaging. This 'Problem' may be ill defined or ill structured for better igniting the motivation of the students. He has also pointed out that – for novice learners, 'Activation' component should be more, while 'Demonstration' should be carefully designed, 'Application' also is important. 'Integration' will improve analyzing skill. Van Merrienboer's (1997) model has 'Application' and 'Integration' in its center. His model treats 'Demonstration' as subordinate to the other two. It further suggests that 'Activation' can even be neglected. Schank's (1999) model on the other hand provides a clear emphasizes on 'Application' limited next only to 'Activation' and 'Demonstration'. 'Integration' although important, will direct the Integration per se, but need not be built-in.

David Merrill's 'First Principles of Instruction'
Merrill divides the instructional event into four phases, which he calls 'Activation', 'Demonstration', 'Application' and 'Integration'. Central to this instructional model is a real-time problem-solving theme, called 'Problem'. Merrill suggests that fundamental principles of instructional design should be relied on and these apply regardless of any instructional design model used. Violating this would produce a decrement in learning and performance. His model is shown in Figure 1

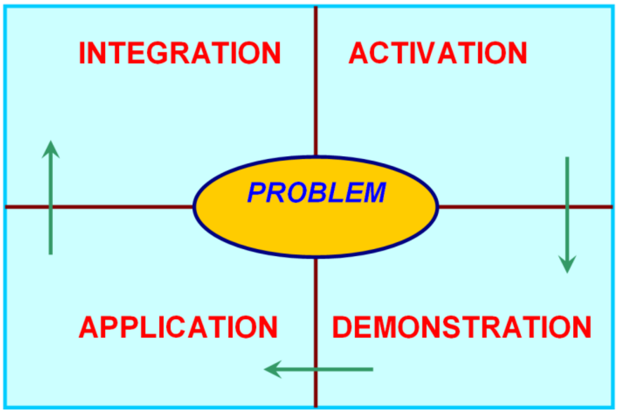

Fig 1 David Merrill's Phases of Instruction
(Reproduced from David Merrill's "First Principles of Instruction")

IV. VALIDITY AND RELIABILITY OF THE TOOLS

4.1 Validity of Content Analysis
The content analysis aimed for the determination on the presence of the four portrayals of David Merrill's First Principles of Instruction in the instructions of the subject contents of the chosen modules. This is descriptive in nature and the presence of these phases is found in all the components of the chosen material. The components are essentially two, namely: i) Slides / frame contents and ii) Notes accompanying the slides in the modules. The presence is summed up and averaged out according to the weightage pertaining to individual instructional time in every slide or notes allocated for every concept of a frame. The weighted average for the entire course is rounded off and presented as approved by an expert committee consisting of the following:

1. Instructional Designer (one)
2. Statistician (one)
3. Research Supervisor (one)
4. Doctoral Committee members (Two)
5. The researcher himself

4.2 Validity of Social Survey

The design of questionnaire started with a collection of already validated questionnaire of similar nature (a validated questionnaire collected through internet on Cooperative Learning, - Concordia University in Montreal, Quebec, Canada has been taken and modified to suite local requirements). Further validity of the modified questionnaire was established through consultations with the experts (Committee detailed above) from the field of different but related functional areas at different phases during the development of the tools. Validity was done in checking on the purpose - of the questions on which the questionnaires were designed. Content validity of the tools can be established by expert judgments of recognized authority (Best and Khan 2002). Determination of Content Validity evidence is often made by expert judgment (Kaplan and Saccuzzo 2001). Established Content Validity evidence for a tool requires good logic, intuitive skills and perseverance. The context of the items must be carefully evaluated (Messick 1998).

Based on these suggestions, the instruments were validated first through a pilot study. A sample of 100 feedbacks was taken for the pilot study conducted on 500 respondents (experts; trainers and trainees - mixed). The feedback responses were then presented to the same team of experts constituted for Content Analysis. Based on consultations held with the experts and with the sample groups of the pilot study, the 'validity' of each item of the tool has been established independently and also the same parameters for the tools were collectively studied. The Content Validity of the tools is thus established. The responses were then scrutinized and minor modifications as suggested by the team were incorporated in the questionnaires and subsequently used for the actual survey.

V. QUANTITATIVE ANALYSIS

Accordingly the analysis performed and results obtained are briefed below. Results are structured according to chapter/section of the e-contents of the subject 'Computer Graphics' of NPTEL. The study has been carried out so as to segregate the textual material into two types namely i) Informative and ii) Instructive – that is demonstrative as per Merrill's definition. This Section is divided into three parts, namely, i. 'Computer Graphics', ii. Graphical User Interface and iii. Computer Graphics Systems. The acronym RWP used in the exhibits represents 'Real World Problem', as per the definition of 'First Principles of Instruction'. Results obtained from each part are presented along with observation.

5.1 Part 1 Computer Graphics
Distribution of Informative Cognitive Structures

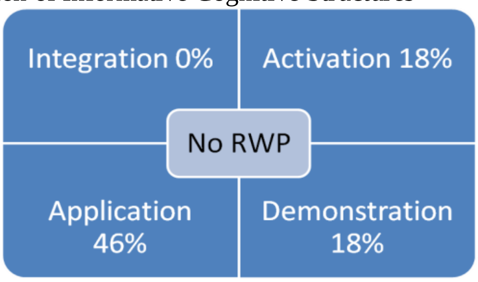

Figure 2: Distribution of Informative Cognitive Structures on Computer Graphics Distribution of Instructive Cognitive Structures:

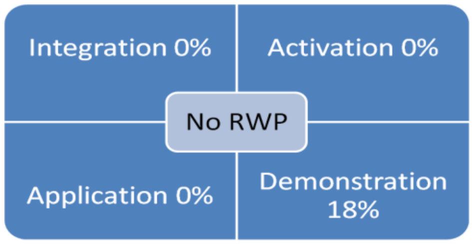

Figure 3:Distribution of Instructive Cognitive Structures on Computer Graphics

Observation: In the 'Introduction' part of the e-content of Section I, 82% (Figure 5.1.1) of the material is informative while the rest (18%) is actually (Figure 5.1.2) instructive (or demonstrative). The maximum represented cognitive structure of the 'informative' portion of the material is 'Application' (46%) followed equally by 'Activation' and 'Demonstration' (18% each). There is no 'Integration' portrayal at all. Whereas, the entire (18% of the) instructive material is found to be demonstrative ('Demonstration' portrayal) in nature. This part therefore does not promote effective learning.

5.2 Part 2 Graphical User Interface
Distribution of Informative Cognitive Structures

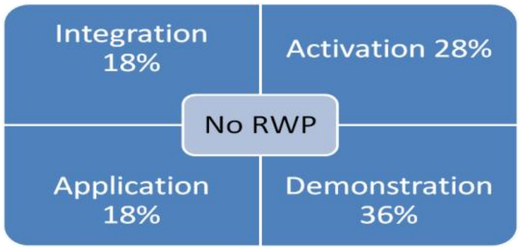

Figure 4:Distribution of Informative Cognitive Structures on Graphical User Interface

Distribution of Instructive Cognitive Structures

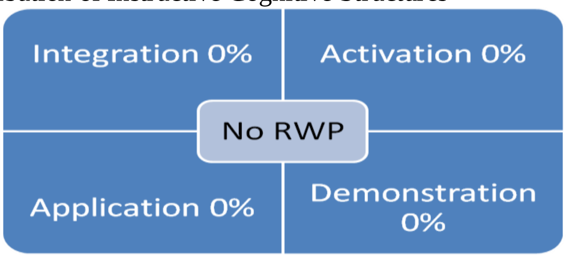

Figure 5: Distribution of Instructive Cognitive Structures on Graphical User Interface

Observation: 100% of the Graphical User Interface material of the e-content is purely informative and not instructive (or demonstrative) in nature. The maximum represented cognitive structure of the 'informative' portion of the material is 'Demonstration' (36%) (Figure 5.2.1) followed by 'Activation' (28%) while the rest are 18% (Figure 5.2.2) each of 'Application' and 'Integration'. Even though all the four cognitive structures are present, the entire part is informative and not instructive. This part also therefore does not promote effective learning.

5.3 Part 3 Computer Graphics Systems
Distribution of Informative Cognitive Structures

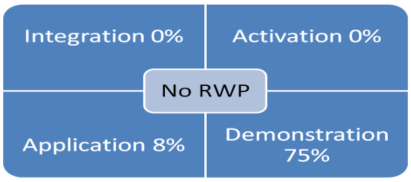

Figure 6: Distribution of Informative Cognitive Structures on Computer Graphics Systems

Distribution of Instructive Cognitive Structures

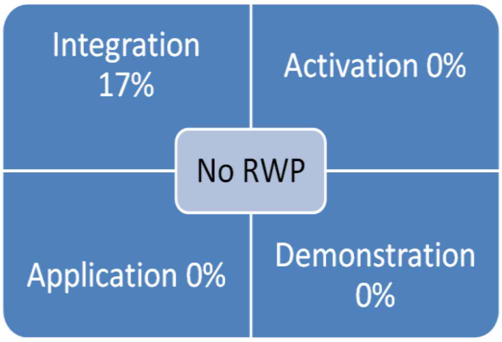

Figure 7:Distribution of Instructive Cognitive Structures on Computer Graphics Systems

Observation: The e-content of 'Computer Graphics System' is once again found to be more informative rather instructive (or demonstrative) in nature. The maximum represented cognitive structure of the 'informative' portion of the material is 'Demonstration' (75%) (Figure 5.3.1) followed by 'Application' (8%) while the rest of 17% is 'Integration' (Figure 5.3.2) but demonstrative in nature. But for activation, this part to a little extent would promote learning, according to the First Principles of Instruction.

5.4 Overall Cognitive Structures

The overall presence of cognitive structures in Section I is briefed along with facts and examples as existing in actual slide.

Example(s)

1. On 'Demonstration'

"Computer Graphics involves display, manipulation and storage of pictures and experimental data for proper visualization using a computer. Typical graphics system comprises of a host computer with support of fast processor, large memory, frame buffer ….."

2. On 'Application'

"Typical applications areas are ….

- Plotting in science and technology
- Web/business/commercial publishing and advertisements
- CAD/CAM design (VLSI, Construction, Circuits)
- Scientific Visualization"

The summary of data pertaining to cognitive structures of instruction is presented in Table 5.4.1

Table 3: Cognitive Structures on 'Introduction to CG'

Part No.	No. of Slides	Title	Informative				Instructive			
			A	**D**	**Ap**	**I**	**A**	**D**	**Ap**	**I**
1	4	Introduction to CG	18 %	18 %	46 %	-	-	18 %	-	-
2	6	GUI	28 %	36 %	18 %	18 %	-	-	-	-
3	5	CG Systems	-	75 %	8 %	-	-	-	-	17 %

The overall presence in the entire Section is summed up and presented.

Distribution among Informative Contents
Activation : 17%
Demonstration: 49%
Application : 24%
Integration : 10%

Distribution among Instructive Contents
Activation : 0%
Demonstration: 51%
Application : 0%
Integration : 49%
Overall informative representation: 88%
Overall instructive representation: 12%

Observation: It is clearly demonstrated that the slide presentations are treated in two instructional styles, namely:

(i) Informative.

Concepts are merely presented with 'What is What' as only information and not describing as 'Why and/or How 'on the conceptual basis.

(ii) Instructive

Concepts are instructed as 'What, How, Why and Where' basis. This kind of instruction is called 'Demonstration' according to the First Principles of Instruction (Merrill – 2007).

Accordingly the slide presentations are grouped into the above two categories. It is evidenced from the content analytical results on this Section, that the 'Informative' presence is much higher (88:12) than 'Instructive' style in this Section I on 'Introduction of Computer Graphics'. It is observed from the three parts that the 'Demonstration' cognitive structure is the predominant portrayal in both the cases. It is also observed that the slides with pictures/diagrams are more instructive rather than informative unlike the slides with textual information.

VI. CONCLUSIONS

It is observed that both the student as well as teacher respondents of South India, when combined with each other have rank ordered "Computer Graphics" as the subject content among Computer Application courses that is most preferable for e-Mode of delivery. This preference is based on concept instructions; usage of multi-media components; possibilities of dividing subject contents/topics into small and independent modules. It is clearly demonstrated through this research study, that the instructional strategy followed in the CG subject e-contents of NPTEL is found to be both informative as well as instructive, and media components have been effectively used. It is also reported through investigation that no explicitly developed instructional model has been adapted. The entire instructive strategy followed is found to be linear. It is concluded that the instructional approach as well as instructional strategy that is to be adapted for e-mode of delivery of CG, needs to be treated differently from that adapted by certain existing techniques used for the same subject content in similar e-Modes of delivery. In addition, the technique proposed by this research study augments many documented findings of literature. The major finding of this research work suggests modular approach in the form of objects for e-content development and delivery. This inference has been clearly demonstrated through experimentation and validation in this research work. These are supported by the experimental and analytical results that are documented in this paper.

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