CHAPTER 1

INTRODUCTION

1.1 E-LEARNING CONTENT DEVELOPMENT AND ISSUES

Adaptation of technologies in education has created new opportunities for interaction in the teaching learning activities (Hansson 2006, Jupp & Griffiths 1990). For example, community of inquiry model (Garrison et al 2000) asserts that true uniqueness of Information and Communication Technology based learning lies in its multidimensional forms of multiplicative communication and interaction. In this way, learners will be able to assume control and directly influence their learning outcomes. Learning, through the ‘www’, has massively connected the world today. As a result, the barrier of place and time apart from social and economic nature have been removed. The demand for e-learning is increasing rapidly throughout the world and the potential for growth is high in developing countries like India, which has huge learner population but with lack of educators etc. (Sangeetha Kakoty et al 2011). As the demand is increasing, researchers must look into issues like standardization for improving the quality of e-learning. E-learning refers to a structured, managed and controlled learning environment and may involve internet, removable media like CDs, Pen drives etc., which heavily use telecommunications and media. The main benefit of using e-learning is cost efficiency, accessibility and flexibility. But developing e-learning contents and deploying them in the internet environment is more expensive than preparing instructional contents for classroom delivery and implementing them in Institutions. This is due to
the fact that creating and applying different media in instruction and automating interactive techniques would cost more. But delivery costs for e-learning that includes costs of web servers and technical support are considerably lower than those for classroom facilities. Besides, instructor time, learner’s travel time, learner’s work time lost to attend classroom sessions etc., are also needed to be accounted for. Another important advantage of e-learning is reach: a wider audience and learners at different levels who have difficulty in understanding subject contents or difficulty in attending classes would be benefitted through e-learning. Because of these merits, designing and developing e-learning content will grow in the future, particularly in India. However numerous issues have already propped up and they need to be addressed with, by researchers.

Improving the quality of e-learning contents, one of the major issues, gets the highest priority (Pulichino 2006). Quality teaching-learning process of Computer Science and Technology demand for certain skill development, namely: i. Cognitive skill for knowing basic principles and comprehending concepts of the subject matter; ii. Procedural skills for following rules and syntaxes and for writing program codes; iii. Problem solving skills for thinking to create algorithms etc. How can e-learning address these requirements? E-learning can cater to pure cognitive skills. But thinking skills require more interaction. Some skills may better be acquired through ‘learning-by-doing’. Some skills may better be acquired through inter-personal relations etc. Another issue is on varying levels of innumerable learners. All learners should receive the same quality of instructions irrespective of their learning levels, because there is no instructor for different levels. It would be virtually impossible to design e-content different for different levels of same subject content. Will it be possible to scale up/down or scale in/out e-content of one subject for different learner levels? Scalability is one of the important software qualities (Duboc et al 2007).
1.2 ESSENCE OF SOFTWARE SCALABILITY

The capacity of a software system that can handle increasing or decreasing loads or user demands at certain time is called as scalable software system. It is concerned with the ability to scale up or down is called ‘vertical scalable’, as shown in Figure 1.1. Vertical scalability deals with functional aspects, like using different components separately. When the size is increased it is scaled up and vice versa. It is also known as upward and downward scalability. For example, if an independent and small base software (module) when added with more material it would then be scaled up. On the other hand, a huge software when deleted with some of its existing material, will be scaled down.

Horizontal scaling on the other hand deals with scaling in or scaling out to or from the boundary (Figure 1.1). It is the architecture that establishes a connection with other software architectures.

![Horizontal and Vertical Scaling Diagram](image.png)

**Figure 1.1 Principles of Horizontal and Vertical Scaling of Software**

New trends in software scalability show concentration towards upward scalability dismissing downward and horizontal scalability (Mohamed Fayad et al 2005). Examples of areas are: increasing speed and capacity, improving efficiency and shifting or reducing the loads. Researchers and designers are expected to pinpoint components in these elements, so that appropriate architectures could be provided.
1.2.1 E-Content Scalability

Literature points out the link between scalability and performance of e-learning systems. Web service technology is mainly used to implement e-learning systems. Several components of e-learning system affect its performance, such as:

i. Effect of instructional theories adopted in the design of e-content;

ii. Nature of learners with different levels and characteristics;

iii. Design of e-content like serial single lot or small independent objects called Sharable Content Object (SCO) etc.;

iv. Role of media components like text, graphics, animation and video;

v. Technical hardware and software details.

In view of the above components, several issues have propped up which have led for identifying the research work. The motivation for the research with the support of literature studied are enumerated.

Vertical Scalability of e-content

Figure 1.2 Vertical Scaling Possibilities of SCOs
Vertical scalability is possible from small independent SCO of different sizes and content. Figure 1.2 shows how hierarchical links from parent SCOs to children are invoked. The merits of such an attempt need to be researched upon and validated. Possible limits with respect to efforts in the form of scaling factors could be derived out of experimental research.

1.3 ISSUES AND MOTIVATIONS FOR RESEARCH

Issues of e-content scalabilities are manifold, as per the vast literature surveyed and reported (Chapter 2). Some of the basic works have been detailed out to identify issues so as to pin point the research problems. These motivating problems are listed out in six categories.

1.3.1 Motivation #1: Need for Content Analytical Study

For maintaining quality of scaled up software systems, quantifiable and testable scalability requirements (parameters) should be arrived at through content analysis of existing systems (Duboc et al 2007). Such studies on existing e-content may require identifying different directions and strategies for scalability of e-contents.

1.3.2 Motivation #2: Need for Evolving Scaling Factors

Scaling factors have been arrived at, based on certain criteria for algorithms (Guy Amir et al 2006). This study provided a clue for the use of scalable factors for algorithmic s/w contents. But non algorithmic data, such as instructional contents need to be arrived for e-learning environment.

1.3.3 Motivation #3: Need for Individual Reusable e-Content

E-content may be divided into small portions known as ‘learning objects’ which may be joined together in order to create a new online course (Maria Zajac 2009, Jonassen & Churchill 2004, Yahya & Yusoff 2008).
Appropriate information structures need to be stored in repositories (McCaulley 1976). They would form individual learning objects. Learning theories and models will be of help in designing such reusable learning objects.

1.3.4 Motivation #4: Need for Evolving e-Content for Different Learner Levels

Learning theories might affect individual learning behavior or learner characteristics (Felder & Silverman 1988, Kolb 1984, Dunn et al 1981). Learners therefore need to choose learning materials according to their learning style preference (Jonassen & Churchill 2004). Different learning objects are therefore must be tried out for different type of learners (levels/characters). How to efficiently develop such individual object for individual learner level is a challenge.

1.3.5 Motivation #5: Need for Arriving Scaling Factors for Different Media Components

E-contents could be stored in different forms like text, audio or video recording, graphic content etc., and the metadata should be well defined (Maria Zajac 2009). Scaling factors needed to be arrived at, based on criteria for multimedia data (Guy Amir et al 2006). Apart from textual e-content data, media components may be considered for arriving at scaling factors.

1.3.6 Motivation #6: Need for Establishing a Proven Instructional Model for Developing e-Content

Learning Objects of e-Learning contents need to be infused with meaningful learning activities like recall, understanding and other abilities using learning theories. Application of Instructional models for the design of
reusable learning objects stressed for effective learning (Jonassen & Churchill 2004).

Instruction models provide a link between learning theories and the methods of constructing instructional systems. Two important instructional design theories are: Cognitive Education and Constructivist Learning. The ‘First Principles of Instruction (FPI)’ (Merrill 2002) is centered on both the above theories. As the FPI is a proven model for e-content development, it would be most appropriate to apply FPI for the design of learning objects.

1.4 RESEARCH OBJECTIVES

1. To investigate the prospects of Non-functional Vertical Requirement Scalable criteria for e-Learning content.

2. To explore the techniques for developing Non-functional requirement scaling factors for vertical learner level scaling.

3. To determine the extent of applying granularity for e-content scaling technique for effectively scaling up different learner levels.

4. To validate and establish scaling factors through experiments and survey.

5. To draw conclusions from the research findings.

1.5 SCOPE OF RESEARCH

The research work delimits its scope into:

1. Sharable Content Objects (SCOs) for e-learning environment of selected subject contents. The e-content is limited to the CS subject area of ‘C Programming Language’.
2. Developmental efforts for modifying existing SCOs for new SCOs in three learner levels. The three levels are delimited with: 1. Diploma, 2. Graduate and 3. Post Graduate learners.


4. Efforts for scaling-up existing SCOs are delimited to three components namely 1. SCO file sizes in memory and storages, 2. Multiples of new frames and 3. Media components.

1.6 THESIS CONTRIBUTIONS

The major contributions of the research are enumerated.

Input 1: The research work has documented content analytical results: Quantified Values of Cognitive Structures of an existing e-content of a public domain known as National Programme on Technology Enhanced Learning (NPTEL) of India.

Research Value: The results will help researchers in identifying suitable instructional model for the e-content.

Input 2: The thesis has documented two major strategies for relying scaling factors, namely i. File size of e-content and developmental effort, and ii. Media components and navigation of e-content and developmental effort.

Research Value: The documented results would show directions for considering other strategies for scalability research.
**Input 3:** SCOs for 9 chosen instructional episodes of three learner characteristics, covering both complexity levels as well as media components have been developed and documented.

- Vertical Scaling Factors on developmental efforts, in values ranging between 0.0 and 1.0 on SCOs of three chosen learner levels have been computed at through a frame work which is proposed by the researcher.

- Scaling factors have been determined for developmental efforts in terms of the four chosen cognitive structures of FPI, a novelty of this research, which may not be seen in existing published works.

- Framework and Scaling factors were validated and established through social survey.

**Research Value:** Findings from the scaling factors and the proposed framework will be of immense use to researchers of e-Learning, Software scaling, and Computer Science and Engineering.

**Utility Value:** The findings will help e-content designers in designing appropriate SCOs as per the proposed framework and for deciding the scope for scaling base SCO or not for vertical scalability.

### 1.7 THESIS ORGANIZATION

The remainder of the thesis is organized as follows:

**Chapter 2** describes various related works studied from literature survey.
Chapter 3 explains the arrival of strategies for designing e-content. The content analysis of existing e-content has been documented and used for arriving at the strategy. Small sized experiments for deriving strategies are presented.

Chapter 4, an important chapter which elaborates the procedure adopted by the proposed framework, and the computes scaling factors has been presented. Experiments were conducted on different SCOs for different learner levels and scaling factors determined.

Chapter 5 describes validation procedures and presents the optimum scaling factors.

Chapter 6 narrates various conclusions and findings. The chapter also presents possible extension of the research along with recommendations.