Most of the present day e-learning content is developed as a monolith digital repository, which lags the standard data exchange format. Due to this limitation, literature points out to the development of e-learning modules in forms of small and independent units called Sharable Content Object (SCO). The instructional approach of SCOs is considered as a non-functional parameter. Personalized digital repositories from a collection of such SCOs can be combined and delivered separately for specific learner level. Literature also indicates that the pedagogical instructional role when embedded in these learning objects (SCOs) would significantly contribute to the learning context of specific e-learner level. But designing and developing independent SCOs for different learner levels would be costly and unnecessary for similar or same subject contents. At the same time, the anticipated changes needed in the respective e-contents might be marginal, and the presentation styles might also be slightly different from that of a simple and common base SCO, in upgrading SCOs for similar but different learner levels. Therefore determining the ‘possibility of’ and ‘technique for’ scaling-up of appropriate SCOs from the base SCOs for suitable learner levels would be a viable research proposal. Scalability is the ability of a system to be enlarged to a new system. The question: To determine whether substantial efforts are needed to develop new SCOs or scale-up existing SCOs for vertically (upwardly) higher levels of learners would be beneficial? This
issue, which needs to be addressed and researched upon forms the background of the research work.

Literature points out to the fact that scalability on instructional contents of e-Learning can also be tried out. It indicates that SCOs need to be infused with meaningful learning activities. It was stressed that quantifiable and testable scalability parameters may be obtained, so as to maintain quality of scaled up systems. As indicated by literature, content analysis on the existing systems needs to be done. Hence as a first step, such studies on an existing e-content may be required for identifying strategies for the investigation of scalability of e-contents. How to efficiently develop such individual object for learner level from lower level to higher level (vertical) is a challenge for the research. Two important instructional design theories, namely, Cognitive Education and Constructivist Learning have been proposed for e-contents by literature. The ‘First Principles of Instruction (FPI)’ is centred on both these theories, for e-content development; it would be the most appropriate model (base) to apply for developing learning objects for the experiments (research).

In view of the above, the research has brought out five major objectives: To investigate the prospects of Non-functional Vertical Requirement Scalable criteria for e-Learning content; To explore technique for developing Non-functional requirement scaling factors for vertical learner level scaling; To determine the extent of applying e-content scaling technique for effectively scaling up different learner levels; To validate and establish scaling factors through experiments and survey; and To draw conclusions from the research findings.
As a first step towards the research work, an attempt is made to analyse the existing e-content of a well known e-learning public platform of India, known as NPTEL. This content study yielded interesting results, like, no learner characteristics have been specified for any of the NPTEL’s courses; course contents are digital equivalent of printed book; course contents are bundled into a single module; no explicit instruction model has been adopted; and course content is virtually not possible to scale up or down to any learner level. Apart from the above, the actual presence of cognitive structures in the NPTEL e-contents of ‘C Language course’ has been studied and documented. Besides, the study also indicated strategic components that should be founded for the design of standard e-content material, such as application of SCO.

Three learner levels, namely, Diploma, Degree and Post Graduate (PG) levels of one common subject content namely “C Language” was considered. It is proposed to develop base SCOs that have the minimum quantity of instructions. Quantifiable cognitive structure can thus be used as base for the design. The research work attempts to demonstrate the possibilities of scaling up of these base SCOs in terms of the four Cognitive structures of FPI for a specific learner level (Diploma or Degree or PG), thus making a total of 12 SCOs for any chosen three learner levels of each topic of the subject. Scaling factors would be arrived at through the proposed experimental studies for each SCO. The objective of the research is to establish the relationship between the scaling factors and the feasibility of scaling in vertically upward manner according to the desired learner level. For the purpose of finding out scaling factors, a one minute duration as a
fundamental unit of instruction is considered under a parameter \( \varepsilon \). \( \zeta = \text{Total duration of SCO retention time in terms of } \varepsilon \). The principle behind introducing this instructional duration factor is: in a large retention SCO, the duration required for a learner level will be more, and then it might be worth scaling from the base SCO rather than for a short instructional of the same base, for different learner level. The scaling factor will be defined by a value between 0.0 to 1.0, as \( \alpha \) which is the ‘developmental effort scaling factor’ for each cognitive Structure of a value between 0.1 and 0.9. The developmental effort factor, common factors for a fresh development of new additional frames and media components on the ‘development effort scalability’ are also considered in terms of the four cognitive structures. The validity and the reliability of this frame work were demonstrated through a social study. The scaled up SCOs of the three levels were administered with certain selected control group of e-learners and feedbacks were obtained. The statistical results were then compared with the scaling factor of SCOs that were experimented. The degree of scaled up SCOs and the quality of instructions tallied well with each other, thus demonstrating the applicability of the chosen parameters for determining the scaling factors.

The thesis has limited its scope to developmental efforts of SCOs for scaling up/down existing SCOs. Besides, the research work delimits its scope to a specific domain namely ‘Programming Language’. Yet again the research work deals with vertical learner levels limiting to three levels. Bearing in mind with these limitations, important conclusions and findings are extracted only to these limiting components. These concluding remarks on the effect of SCO, scaling factors and cognitive structures have been documented.