Conclusions & Next Steps

7.1 Conclusions

In this thesis, we aimed at creating an approach for design of educational technologies to address scale and variety in education. Specifically, we addressed the need to support creation of eLearning Systems for flexible instructional designs and multiple Indian Languages in the context of adult literacy in India. The fundamental basis of our approach is to design educational technologies based on instructional design for quality of instruction. To this end, we relied on commonly accepted teaching/learning methodologies and instructional material based on these methodologies.

Based on principles from computing, we explored the possibility of extending and applying software engineering approaches like patterns, ontologies and software product lines to address the challenges of scale and variety. The first step in the proposed approach is to systematically model different aspects of instructional design using patterns. We have discovered two patterns: ProcessPattern, that organizes instructional process in the form of plays, acts, scenes and instructions and ContentPattern that organizes instructional material as facts, cases, rules, models and theories. To adhere to quality of instruction, the ProcessPattern and ContentPattern are mapped to Merrill’s First Principles of Instruction and Bloom’s taxonomy respectively. Based on the patterns that encapsulate practices in instructional design, we proposed an ontology based modeling framework with a set of ontologies (context, goals, process, content, evaluation, environment) to concretely represent the patterns and facilitate automation. This ontology framework is based on standard ontologies for learning design (process) and instructional material in the literature. After modeling the domain using patterns and representing them using ontologies, we presented a pattern-oriented software product line approach for modeling families of instructional designs and families of eLearning Systems for adult literacy. To demonstrate our approach, we have
created a prototype platform for modeling instructional design variants and a prototype platform for semi-automatically generating eLearning Systems for adult literacy.

In the next section, we briefly outline the next steps as well as some future directions of the thesis.

7.2 Future Research Directions - Beyond this thesis

We see the following potential extensions of this thesis:

7.2.1 Pattern Modeling Languages and Pattern Composition

While using patterns facilitates reuse and is based on instructional design, we see the following future research directions:

• Modeling notations for representing patterns and supporting techniques and tools for handling patterns throughout life cycle.

• Formal approaches for composing patterns either within the domain or software or between domain and software, validating assembly of patterns and their integration.

7.2.2 Ontology and Pattern Modeling Life Cycle

We have extended and created several ontologies in our ontology framework proposed in Chapter §4. However, by definition, every domain can have several perspectives and hence several ontologies. In our ontology framework, we have introduced the notion of meta-ontologies for representing high level aspects of instructional design like process and content, which are then customized for specific cases of Merill’s First Principles of Instruction and Bloom’s taxonomy. With this context, the following are some potential directions for further research:

• Creating ontologies for different aspects of instructional design catering to the diversified needs of a wide variety of subjects at different levels of education to be delivered in multiple languages and on a wide variety of different platforms requires massive collaborative effort from multiple disciplines.

• Creating collaborative, distributed and agile environments for domain and subject matter experts to create, share and disseminate their patterns and ontologies is a critical step towards design of educational technologies for scale and variety.

• In addition, it becomes increasingly difficult to manage the magnanimous number of patterns and ontologies motivating the need for life cycle management tools.
7.2.3 Software Product Lines for Personalized Learning

Even though the software product line approach outlined in Chapter § 5 is a natural way to address scale and variety of educational technologies, personalized learning is a grand challenge for computing requiring further research from software product lines community.

• Using current feature modeling notations, features can only be selected for product configuration but the need in educational technologies is to have features that have knowledge associated with them for different aspects of instructional design like goals, process steps and content, which is not possible with current notations. For example, expressing goals using Bloom’s taxonomy or ABCD technique could be a feature but specifying an exact learning goal requires more than just features.

• Design of light-weight approaches for SPL for educational technologies domain is a definite need as instructional design itself is a complex activity.

• Educational technologies domain presents the need for a family of product lines catering to the needs for variety at multiple levels.

• The socio-technical nature of education domain motivates the need for SPLs that are spread across domains like learning methodologies, software engineering and human-computer interaction.

• Design of SPLs that span across different organizations from different domains.

• Facilitating assembly of educational technologies from open educational resources and further customizing them for personalized learning requires research in every aspect of software product lines from scoping to all aspects of domain and application engineering.

• In addition, lean and globally distributed software product lines could be two potential research directions for addressing the challenges of designing educational technologies for personalized learning.

7.2.4 Educational Technologies Beyond Adult Literacy

The approach presented in this thesis can be applied for design of educational technologies beyond adult literacy. Skill education is undergoing a major revamp in India extensively supported by Government of India through National Skill Development Corporation (NSDC). NSDC has set up 38 Sector Skill Councils pertaining to different industrial skills like automotive, healthcare and so on. Model curriculum\(^1\) for different sectors and

\(^1\)NSDC, http://www.nsdcindia.org/model-curriculum