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Elaborated Feedback for Online Assessment Systems

A dissertation by

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Declaration

I hereby certify that this project report and all the artifacts associated with it is my own work and it has not been submitted before nor is currently being submitted for any degree programme.

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Abstract

In traditional learning, teachers provide individual feedback and recommend LM to improve the students' knowledge and to motivate, based on the skills and personality of the student. But in e-learning, there is no role of a teacher. The e-learning systems provide lot of learning materials for the students after an exam regardless of matching reading materials with the students' knowledge and their reading preferences. If the e-learning system does not provide learning materials students tend to google. Following both these approaches create the overloaded information problem since the students cannot identify the best article suddenly through web. Due to this problem a solution is suggested with recommending learning materials to students based on their knowledge, interaction data, learning style model with their reading preferences. A novel way of mapping students' knowledge, interaction data and reading preferences is introduced by the solution and in order to develop the solution model was selected as the LMS and creating feedback with the learning material recommendations is implemented as a REST service. The problem is addressed considering the software engineering students who tries to do online assessments.

The proposed system was evaluated by evaluators of various domains. Eventually, the test results attested that the analysis, design, implementation and documentation have been carried out in an effective and in an efficient manner.

Subject Descriptors:

G.4. Mathematical Software

H.3.2 Information Storage

H.3.3 Information Search and Retrieval

Key Words:

Recommendation Engine, Machine Learning

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I would like to express my special gratitude and thanks to everyone who assisted me by participating online surveys, interviews and contributing their ideas for requirements gathering and critical evaluation and also for all who helped with the user based testing for Elaborated Feedback Generator.

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Table of Abbreviations

Abbreviations	Definition
API	Application Programming Interface
CBF	Content Based Filtering
CF	Collaborative Filtering
FAS	Feedback Adaption Systems
FSLSM	Felder-Silverman Learning Style Model
GNU	General Public License
HTTP	Hypertext Transfer Protocol
JSON	JavaScript Object Notation
KLSM	Kolb Learning Style Model
k-NN	K-Nearest Neighbor
LCC	Learner-Centered Content
LM	LM
LMR	Learning Material Recommendations
LMS	Learning Management System
LSM	Learning Style Model
MCDM	Multi-Criteria Decision Making
NLP	Natural Language Processing
NNA	Nearest Neighborhood Algorithm
OOADM	Object-Oriented Analysis and Design Method
PM	Preference matrix
REST	REpresentational State Transfer
REST	Representational State Transfer
RS	Recommendation System
SOAP	Simple Object Access Protocol
SSADM	Structured Systems Analysis and Design Method
TOR	Terms of Reference

UML	Unified Modelling Language
URL	Uniform Resource Locator

Elaborated Feedback Generator

Chapter 1: Introduction

- Chapter Overview
- Project Overview
- Motivation
- Project Aim
- Project Objectives
- Features of the Prototype
- Project Deliverables
- Resource Requirements
- Activity Schedule
- Chapter Summary

1.1. Chapter Overview

The purpose of this chapter is to come to an agreement with the supervisory body about the outline of the project on the structure, main purpose with aim and objectives, plan and the requirements of the project.

This document briefly describes the factors that inspired to undertake the mentioned research project. It also includes the importance of doing it, an introduction to the online assessment feedback systems with recommendations, previous work, the aim, and objectives for successful completion of the project, features of the prototype, project deliverables and resource requirements.

1.2. Project Overview

1.2.1. Project Background

E-learning is not an untouched research area. It has revolutionized the educational experience and it is getting better day by day by providing a more effective experience for the learner. Many people are using e-learning to polish up their knowledge, gain degrees and to develop new skills. To meet this growing demand many e-learning systems with different features are emerging in the current days. Among the different e-learning methods, online assessments are quite famous in the modern days and most of the universities use online assessments during their day to day assessment process.

After an assessment in the traditional learning environment, teachers provide individual feedback and recommend LM to students in order to improve their knowledge and to motivate. The feedback and LM given by a teacher is based on the skills students show in a particular exam, students' personality and the day to day skills exhibited by the student. But in e-learning, there is no role of a teacher and the students lack motivation, proper guidance, and difficulties in finding LM to read in order to improve their knowledge. Many researchers have found that the above problem which is the lack of interaction between the teacher and the students is one of the main problems in online learning applications and this is a major concern for providing feedback in online assessments too (Arbaugh, 2000).

Learning by doing is one the most effective method in e-learning. Which means that students gather knowledge via feedback received from online assessments. So that the feedback in e-learning replaces the role of the teacher who provides comments, advices, recommend LM and evaluates the students in traditional learning environments (Vasilyeva et al., 2007).

The feedback with suitable learning material recommendations given in an online assessment is the main influence on students to achieve the next step. Feedback has been described as "the most powerful single

moderator that enhances achievement" (Hattie, 1999). The feedback provided via an online assessment should fulfill the main objectives such as:

- Justify to students how their mark or grade was derived.
- Identify and reward specific qualities in student work.
- Guide students on what steps to take to improve
- Motivate them to act on their assessment
- Develop their capability to monitor, evaluate and regulate their own learning (Nicol, 2010)

Feedback is valuable when it is received, understood and acted on. How students analyze, discuss and act on feedback is as important as the quality of the feedback itself (Nicol, 2010). The properties of the feedback are important in applications with large user groups having a variety of individual characteristics and goals. Feedback adaptation offers possibilities to deliver feedback that is the most appropriate for the user's skill level, personal characteristics, mood, behavior, and attentiveness (Vasilyeva et al., 2008).

At the same time, feedback should function as a motivator on the emotional level, reinforcement as a concept on the behavioral level and provider of information on the cognitive level of function or analysis. These levels are especially important in the e-learning systems.

1.2.2. Problem Domain

E-learning can provide better support for the less able, engage students who do not respond well to 'traditional' classroom learning, provide the opportunity for accelerated learning for gifted and talented students, and develop independent learning skills through a personalized learning experience (Boulton, 2008). If the feedback is not fulfilling at least its main objectives, that assessment is not going to benefit the student or the e-learning system. The lack of full knowledge about student's cognitive ability, learning style and real time affect status are the problems in generating elaborated feedback with recommendations. It has been identified that "the majority of feedback provided is missing the influence of instructors' reaction to students' affect status, which is important when understanding the students' cause for a mistake" (Morton and Qu, 2015).

When designing online assessments generating feedback with accurate learning material recommendations is the most difficult task. There exists a lack of full knowledge about student's cognitive ability, learning style and real time affect status in recommending learning material. The learning material recommended without considering the above personalization factors may lead to information overload since the materials recommended are not matched with the student's skills and the student have to search for many LM and the student is not sure about

what material might help him. So, when the feedback is made without considering those factors feedback will be destructive to the student. Which will finally lead the student to drop the course instead of learning something.

In order to reduce information overload problem in e-learning applications, the feedback provided should contain LM based on user:

- Knowledge - Background, Experience, Goals, etc.
- Personal Data - Age, Culture, Attention, Memory, etc.
- Interaction parameters - Chronometric data, Try data, etc.

Although the importance of feedback adaptation has been found, there hasn't been any completed software solutions for feedback adaptation with recommending learning material, which fulfills, at least, the main objectives of online assessments. By including learning material recommendations to e-learning environments, the 2 problems of personalization and information overload can be addressed. In this situation, recommender system offers which learning objects should learners study next, or offers learning objects in order to contribute to the learners' progress towards particular goals.

Therefore, an online assessment system is proposed with learning material recommendations, which fulfills main objectives of online assessments considering the tasks and the personality of a user to improve the quality of e-learning by providing a solution to overloaded information problem. The problem is addressed considering the software engineering students who try to learn programming languages online and test their knowledge through online assessments.

1.2.3. Previous Work

Previous work can be found in the Appendix A previous work section.

1.3. Motivation

Being an e-learning user who learns different programming languages/technologies individually, has come across with several problems when checking knowledge using online assessments. Some of the problems experienced were:

- Feedback received are not matched with the knowledge of the user
- Does not provide LM to match with the user learning styles
- Feedback provided are not adapted to the user environment
- Too much of learning material is suggested and some are irrelevant.

Due to these problems, the users are unable to cover their expected goals from the online assessment system. The fact that, a solution does not exist to date, that solves all of these problems, is the major motivation behind the proposed solution.

1.4. Project Aim

To design, develop and evaluate an online assessment feedback system with adapted feedback which recommends learning material to reduce the lack of interaction problem and information overload problem in e-learning systems.

Further elaborating the aim, this project will produce an online assessment feedback system with personalized and elaborated feedback with recommendations according to the following user characteristics.

- Knowledge
  - Ex: If the user is making the same mistake repeatedly the solution can generate feedback, including a detailed explanation of where the student went wrong. The feedback can be started with following the user's knowledge. Which means, of finding out which theories/concepts that the user is mastered
- Personal data
  - Ex: The feedback can be personalized according to the user name, gender, age, etc. The use of personal data is to give the user the feeling that it is personal to him. This is because it is the first thing which makes the user feel that the feedback is personalized.
- Interaction parameters
  - Ex: The number of attempts taken, Time taken to refer related articles

The proposed solution will not cover adaptation of feedback to a group of users or a stereotype.

1.5. Project Objectives

To achieve the aim of the project some of the objectives are defined in the below table 1.1.

Objective 1:	**Prepare terms of reference**
• Prepare the TOR document, including the project background, problem domain, previous work, project aim, project objectives, features of the prototype, project deliverables, resource requirements and the project plan which will be a guide throughout the project life cycle. • Submit draft TOR. • Submit final TOR after evaluation.	

Expected output artifact: Terms of reference document	
Objective 2:	**Project planning and management**
• Conducting risk analysis • Drawing work breakdown structure • Writing activity schedule (grant chart) • Selecting a software development methodology Selecting a recursive software development methodology which will carry out the different phases of the project in a recursive way. **Expected output artifact:** Project planning and management chapter	
Objective 3:	**Conduct a literature survey**
Conduct in-depth literature survey in the following areas: • Characteristics of feedback given from online assessment systems – To understand how the online assessment systems works and how relative the feedback given from those systems. • Gain knowledge about what other individuals and organizations have found in the research area and how they tried to develop or design the solution – To understand the techniques, technologies and algorithms used in existing online assessment systems to provide feedback. • Find out undiscovered problems and unresolved problems in online assessment feedback systems with learning material recommendations – To understand the problem domain. • What can I do to fill up those gaps – To provide the solution. • Different development technologies to determine the best approach to follow to fill those gaps. **Expected output artifact:** Literature review document	
Objective 4:	**Requirement gathering**
Carry out an in-depth user requirement gathering phase with: • Selecting and justifying elicitation techniques • Selecting and justifying analysis tools • Execute elicitation techniques ✓ End users of online assessment system users through a questionnaire and observation of online assessment systems to identify the end user requirements and behaviors. ✓ Domain experts of online assessment feedback systems to identify the standards of online assessment feedback systems and current processes to provide feedback along with their suggestions to make feedback more appropriate.	

- ✓ Domain experts who have done previous researches about the importance of elaborated feedback.
- ✓ Personal evaluation of the existing online assessment feedback systems to verify the end user requirements and domain expert ideas and identify any possible new requirements.

- Analysis of requirements
- Documenting SRS
  - ✓ Using the data gathered through literature review, end-user questionnaire and observations, domain expert interviews and personal evaluations, prepare the software requirements specification to document the functional and non-functional requirements of the proposed system.

Expected output artifact: Software requirement specification document

Objective 5:	**Designing the prototype**

- Select the most appropriate technologies and tools to develop the proposed solution.
- Prepare the design specification for the prototype according to the analyzed requirements gathered in requirement gathering phase.

Expected output artifact: Architecture Specification, Decision analysis reports

Objective 6:	**Implementation**

- Develop the prototype to full fill user requirements.

Expected output artifact: Software prototype

Objective 7:	**Testing the prototype**

- Create a test plan and test cases
- Conduct in-depth testing of the system to identify bugs and check whether the required functional and non-functional requirements of the users are achieved from the developed prototype.
- Fix the bugs if there are any

Expected output artifact: Test results

Objective 8:	**Evaluation of the work carried out**

- Carry out a critical evaluation of the prototype using selected user groups of the system and conduct a review of the evaluation findings to determine how far the project has successfully addressed the hypothesis
- Carry out a review with domain experts in different research areas used in the prototype to identify areas for future improvements
- Perform a personal evaluation to self-assess the work carried out

Expected output artifact: Review document

Objective 9:	**Documentation and Submitting final prototype**

• Documenting key findings of the research • Documenting key steps involved in the project prototyping and testing • Submitting project proposal, interim project report, draft project report and bonded project report **Expected output artifact:** Final project report

Table 1.1: Project objectives (Self composed)

1.6. Features of Prototype

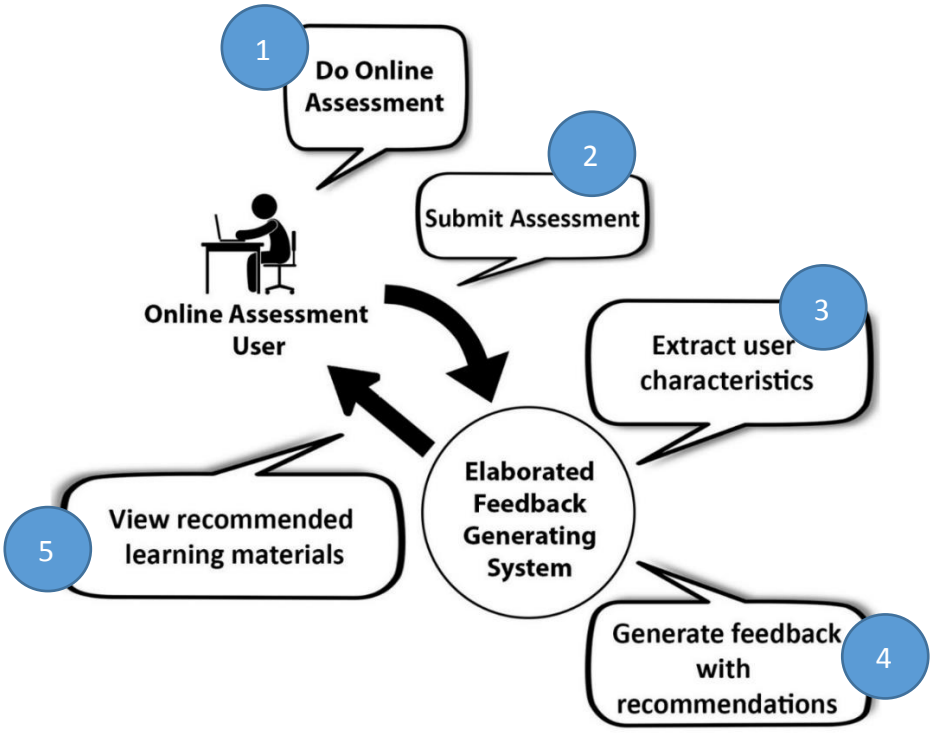

Figure 1.1: Features of the prototype (Self composed)

As shown above, figure 1.1 shows the features of the prototype. Further, they can be mentioned as below.

1. Online assessment user should allow doing the assessment. This assessment is created by the system taking questions from the question database.
2. Online assessment user should able to submit the assessment
3. The system should be able to extract user characteristics
4. The system should create elaborated feedback with recommendations to a particular user based on the factors identified to personalize feedback.
5. Online assessment user should present with an elaborated feedback.

1.7. Project Deliverables

- Draft Terms of Reference
- Terms of Reference
- Literature Review
- Requirement Specification
- Software Design Document
- Interim Report
- Prototype Report
- Draft Project Report
- Project Report
- Project Prototype

1.8. Resource Requirements

* The resource requirements are subjected to changes.

Hardware Requirements	Software Requirements
• Core i5 2.13 GHz processor • 4 MB DDR3 RAM	• Online assessment creation tool • Recommendation engine • Java SDK 1.6 • PHP • Java Script • IntelliJ IDEA • Microsoft Office package • Star UML

Table 1.2: Resource requirements (Self composed)

1.9. Activity Schedule

Refer to the attached activity schedule in Appendix B.

1.10. Chapter Summary

The chapter started with providing the project background and the problem domain. It was identified that the proposed solution will provide answers for the lack of interaction problem and the information overload problem in e-learning systems. The project motivation and the aim were described. As aimed an elaborate feedback generator with learning material recommendations will be developed for online assessments and enable individual users to create online assessments, do online assessments and view elaborated feedback with recommendations are the main features identified. The system will generate the elaborated feedback based on online assessment users' personality and characteristics such as knowledge, personal data, and interaction parameters. Project deliverables with resource requirements were described in the end. Next chapter will discuss about the literature reviews regarding the proposed solution.

Elaborated Feedback Generator

Chapter 2: Literature Survey

- Chapter Overview
- E-learning
- Online Assessments
- Feedback Provided in Online Assessments
- Feedback Adaption
- Measuring Student Knowledge
- Recommending Learning Material
- Chapter Summary

2.1. Chapter Overview

This chapter discusses current published literature related to generating elaborated feedback. It provides critical evaluation, comparison, and a summarized review of the relevant methodologies, algorithms and processes recently researched recommendation techniques, feedback techniques and other critical technologies that will be built upon during the course of this study. The purpose of this chapter is to provide a summarized review of the related research scope and identify the possible approaches to solve the problem.

2.2. E-learning

2.2.1. Critical Evaluation of E-Learning Approaches

E-learning approaches can be individually identified based on the content that they focused.

<table>
<tr><td>Technique</td><td colspan="2">Learner-centered content</td></tr>
<tr><td>Description</td><td colspan="2">The LCC based e-learning courses are made specifically according to the learner's requirements, characteristics and goals. The learner is responsible for the learning cycle and according to Jonassen et al, (1995) there are 4 main attributes of LCC:
Context – All the activities included in the course are relatable to the learner.
Construction – Learners should be able to match their real world experiences with the subject matter.
Collaboration – Learners are given the chance to solve problems while collaborating with peers.
Conversation – Engage in conversations with peers.</td></tr>
<tr><td colspan="2">Advantages</td><td>Disadvantages</td></tr>
<tr><td colspan="2">Provide personalized experience.
Increases knowledge holding.
Improve critical thinking skills.</td><td>Complexity of creation of the content.</td></tr>
<tr><td>Impact</td><td colspan="2">Since the learner-centered e-learning considers about learner's likes and dislikes, learners get the maximum advantage during the course. But from the perspective of the instructor, the content of the course becomes complex. The technologies and the algorithms to generate the course also get complex.</td></tr>
</table>

Table 2.1: Learner-centered content (Self composed)

Technique	Interactive content

Description	Interactive content based e-learning systems gives the priority to the interactive components to improve the learning abilities. Graphics, charts, videos and sound clips are used more in these systems.
Impact	Interactive learning content makes learners attracted to the course which will make learners stay with the course continuously. The tutors have to spend more time on creating interactive content.

Table 2.2: Interactive content (Self composed)

Technique	Personalization
Description	Personalized learning content is made considering the learners learning needs, characteristics, knowledge and interaction data. The following characteristics can be highlighted as the factors which make the content personalized. • Customized learning content • The way that the learning content is delivered. • The delivery sequence. • The feedback mechanisms offered. • The way learners are evaluated. The content can be personalized by: • Personalizing the learner. • Personalizing the environment. • Personalizing the user roles. • Personalizing learning objectives. • Personalizing learning sequences. • Personalizing the conversation. • Personalizing the navigation. • Personalizing individual competency. • Personalizing the media.
Impact	Impact and more details on the content personalization was described in the chapter 1.

Table 2.3: Personalization (Self composed)

The content personalization effects on an individual than the LCC learning or interactive content learning. The personalization approach also contains the features of other 2 concepts based on the way that is used to personalize the content. It addresses the capabilities of an individual uniquely and this will impact on learner to gain knowledge more than the other concepts. Due to these reasons personalization of content can be suggested as the best e-learning approach.

2.2.2. Critical Evaluation of E-Learning Techniques

Technique	Lesson-based podcasts

Description	Lesson-based podcasts are recordings, including a small amount of information which will make the learners to think widely.
Advantages	**Disadvantages**
• Allow users to gain knowledge in less time.	• Technical issues such as difficulty in subscribing to podcast files.
Impact on improving knowledge	Users may tend to lose their concentration while listening due to these podcasts has lesser impact on improving learners' knowledge.

Table 2.4: Lesson-based podcasts (Self composed)

Technique	Games
Description	Games are developed in order to provide knowledge in particular subject matter.
Advantages	**Disadvantages**
• Provide the ability of catching up the lessons without a burden and more experience. • Allow learners directly involve with the lesson.	• Major time-waster, taking away from the time that a learner could spend studying or being active. • Addiction may cause social isolation.
Impact on improving knowledge	Users tend to addict to the game rather than paying attention to the educational content included. So that there are chances that a game will create no impact on knowledge improvement of a user.

Table 2.5: Games (Self composed)

Technique	Instructional videos
Description	The videos are used to provide explanations, site design or to describe advance algorithms.
Advantages	**Disadvantages**
• Facilitating thinking and problem solving. • Inspiring students.	• More production time.
Impact on improving knowledge	Inspired learners tend to gather knowledge faster and these videos make learners focused on the course dude to input learners' get from eyes and ears.

Table 2.6: Instructional videos (Self composed)

Technique	Online assessment and quizzes
Description	Assessments are made with both close ended and open ended questions.
Advantages	**Disadvantages**

• Easy to repeat. • High degree of customization in the feedback students get in response to each answer that they submit. • Asynchronous and can be accessed on a variety of devices. • More interactive. • Instructors can better serve students by providing them with custom made study aids. • Automatically grade student responses, saving time for the instructor.	• May contribute isolation. • Close ended questions lack of creativity. • Creating assessments may take time. • Cheating on an online test is simple.
Impact on improving knowledge	Engaged learners gather knowledge faster and the knowledge they gain will remain for a long period of time. The assessments can be used as a motivator to make learners learn and to help learners remember the subject matters and assess what they learned.

Table 2.7: Online assessment and quizzes (Self composed)

Testing in an online setting is a lot more interactive than traditional paper tests (Gogno. N, 2014). Instructors can embed multimedia in questions in order to provide more attractive assessments. For close ended questions the grading/marks can be provided easily. However, there is no doubt that actively involving students will enhance their education. The learners can get an idea about where they stand and what they have to improve by engaging in an assessment. From the above discussed e-learning techniques, online assessments seem to have more effect on a learner than the other techniques. Although it has few disadvantages, they are inconsiderable when compared with the advantages of other techniques.

2.3. Online Assessments

2.3.1. Critical Evaluation of Online Assessment Techniques

Technique	Traditional assessment submitted online
Description	The assessments such as essays, reports, reviews and case studies done by students are submitted online.
Advantages	**Disadvantages**
• Plagiarism detection and the peer reviewing is made easy.	• Automated marking is difficult. The algorithms used should be accurate.
Impact on learner	**Impact on tutor**
• Learns does not need a much technical knowledge to perform the assessment.	• Tasks are made difficult for the tutor since automated marking is difficult.

Table 2.8: Traditional assessment submitted online (Self composed)

Technique	Automated assessment
Description	Automated assessments are the quizzes including multiple response, multiple choice, fill-in the blanks, yes/no responses, label matching, ordering options and entering text.

Advantages	**Disadvantages**
• Provides general and specific feedback • Address higher order critical thinking skills. • An automated grading will be provided without much effort. • Maintains quality of the assessment. • Clear formulation of tasks. • Student testing maturity.	• Difficult to detect plagiarism. • Suppressing creativity.
Impact on learner	**Impact on tutor**
• Learners need an average technical knowledge to perform the assessment. • Since the assessment is providing feedback and grading, impacts learner to gain knowledge effectively.	• Have to spend much time on creating the assessment.

Table 2.9: Automated assessment (Self composed)

Technique	Invigilated online exams
Description	These contain both open ended questions and close ended questions. There is also an invigilator is present in the exam environment in order to follow the standards.

Advantages	**Disadvantages**
• Easy to detect plagiarism.	• More rules and standards to follow. • Need a special environment to execute.
Impact on learner	**Impact on tutor**
• Learners need an average technical knowledge to perform the assessment.	• Have to spend time on marking the assessments.

Table 2.10: Invigilated online exams (Self composed)

Technique	Authentic assessment
Description	Authentic assessment is scenario based learning. There are Role plays, Online oral presentations and debates take place as a part of the assessment.

Advantages	**Disadvantages**
• Including self and peer review features	• Time-intensive to manage, monitor, and coordinate

• Focuses on analytical skills and the integration of knowledge • Promotes creativity • Reflection of real-world skills and knowledge	• Challenging to provide a consistent grading scheme • Challenging to develop for various types of courses and ranges of objectives
Impact on learner	**Impact on tutor**
• Learners need an average technical knowledge to perform the assessment. • Make learners' gain knowledge easily and stable.	• Difficult to assess and grade students, which will impact on a time wastage.

Table 2.11: Authentic assessment (Self composed)

Considering the advantages, disadvantages and the impact caused, it is clear that the automated assessments can be done in any kind of an environment and contains the least number of sets of rules to follow when compared with other techniques. So that the automated assessments can be suggested as the best assessment techniques and it is also the most popular among students.

2.4. Feedback Provided in Online Assessments

2.4.1. Critical Evaluation of Feedback Concepts

The theory of feedback is used in many fields of science: psychology, education, biology, economics, and information systems, each having own perspective (Vasilyeva et al., 2007). Feedback in all those are considered as a kind of a circle from an output of a certain action to input.

2.4.1.1. Wiener's Feedback Concept

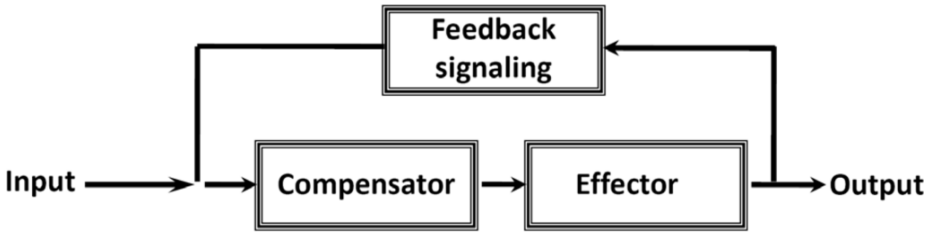

Figure 2.1: Wiener's generalized feedback process (Wiener N., 1948)

Description	Wiener's definition of cybernetics contains two paired concepts. He was clear that control and communication were highly related concepts, and could be expressed in terms of feedback. Wiener regarded "negative feedback as important and useful than positive feedback, leading to stability and effective control". He saw positive feedback as dangerous and unstable (Wiener, 1948). The wiener's generalized feedback process is displayed in the above image. Wiener used

	the feedback concept to differentiate processes by which a control unit gets information about the effects and the results of actions.
Impact on accuracy	According to Spink and Saracevic (1998) the Wiener's concept is viable in respect to engineering applications, but extension into human activities contains many problems. Social sciences and information aspects of feedback should be added to the cybernetics perspective.

Table 2.12: Wiener's feedback concept (Self composed)

2.4.1.2. Feedback Triad

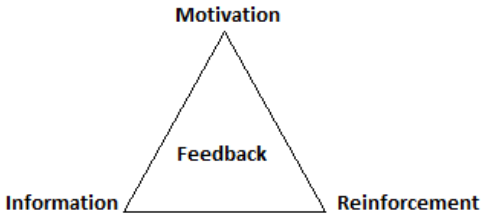

Figure 2.2: Feedback triad (Kulhavy and Wager, 1993)

Description	Kulhavy and Wager (1993) introduced the concept of a feedback triad using the following definitions of feedback. • "Feedback as a motivator for increasing response rate and/or accuracy" • "Feedback reinforcing a message that would automatically connect responses to prior stimuli - the focus being on correct responses" • "Feedback providing information that learners could use to validate or change a previous response - the focus being on error responses" (Kulhavy and Wager, 1993).
Impact on accuracy	As shown in the above figure, the feedback should act as a motivator, a provider of information and reinforcement at the same time. Reinforcement can be seen as a concept at the behavioral level, motivator on the emotional level and provider of information on the cognitive level of function or analysis. Since it considers the main features that a feedback should contain, the feedback generated through the concept will have more effect on a learner with high accuracy.

Table 2.13: Feedback triad (Self composed)

Since the social science aspect of Wiener's feedback concept in not that strong, the feedback triad concept can be suggested as the best feedback concept developed up to now.

2.4.2. Feedback Classification

One of the main feedback classifications is the categorization of feedback into negative and positive.

	Positive feedback	Negative feedback
Description	Resulting action is in the same direction as the condition that triggers it.	When the resulting action goes in the opposite direction of the condition that triggers it, then the feedback is called negative.
Features	• Informative • Can be used in certain situations where quick change is desirable.	• Non informative
Advantages	• Tends to increase output and speed up the process. • Highly responsive. • Increases motivation	• More stable, because the system becomes more immune to changes of the input. • Prompts improvements
Disadvantages	• Less stable.	• Less responsive.
Impact on learner	• There is a chance that a learner may over think about his knowledge.	• There is a chance of demotivating the learner.

Table 2.14: Positive feedback vs negative feedback (Self composed)

Another main classification parameters of the feedback are based on how much and what kind of information it provides. Mory (2003) uses the term feedback complexity.

Classification Type	Description	Impact
Knowledge of response feedback	Indicates whether the answer was received. Anyway, it does not mandatory to give the response or information about the accuracy or inaccuracy of the answer.	This will not stand alone motivates the user to learn.
Knowledge of result	This informs the user of a correct or incorrect response.	This will not stand alone motivates the user to learn or to gather knowledge.
Knowledge of correct response	This gives the correct answer (Ross and Morrison, 1993). This is also known as corrective feedback.	This will also not individually help users to gain more knowledge.
Answer until correct or try-again feedback	This is a modification of the knowledge of response feedback. The user is engaged in active error detection and is given several additional attempts to get a correct answer.	This may motivate the learner to do a question until the correct answer is found.

Elaborated feedback	Presents not only the correct answer, but also some additional information.	This may motivate the learner to stay with the course gain more knowledge.

Table 2.15: Feedback classification according to complexity (Self composed)

Feedback can also be classified by the time of presenting as immediate and delayed.

	Immediate feedback	**Delayed feedback**
Description	Immediate feedback is corrective, informative feedback given to the user directly after the answer to the task.	Delayed feedback is informative, corrective feedback presented after the group of tasks, the whole test, or, after some period when the test is performed.
Advantages	Maintains the user's attention, motivates him, and reduces unproductive floundering	Contribute to better memory and transfer of skills.
Disadvantages	Students do not get a second chance to rethink and do the question.	Some students may forget about the questions when they receive the feedback.
Impact	The impact may differ based on the other factors affecting improving user knowledge.	

Table 2.16: Immediate vs delayed feedback (Self composed)

According to grading information feedback is classified into formative and summative.

	Formative feedback	**Summative feedback**
Description	Provides information about the learner's progress within the course. It includes grades, but it goes beyond grades with comments on written papers, brief conferences, or evaluations (Dirks, 1997).	Summative feedback is a final report on the learning outcomes and is characterized by the final grade (Dirks, 1997).
Impact	Formative assessment can identify the areas that may need improvement.	Summative feedback provides less motivation for the user than formative feedback.

Table 2.17: Formative vs summative feedback (Self composed)

Feedback can be classified into predefined, adaptable and adaptive feedback according to the adaptation possibilities.

	Adapted feedback	**Adaptable feedback**	**Adaptive feedback**

Description	Predefined feedback assumes that the feedback settings are predefined before the interaction process.	Adaptable feedback is the feedback which is customized by the user during the interaction process.	Adaptive feedback unlike adapted feedback is dynamic. It allows varying feedback settings for different users according to their individual characteristics and performance.
Impact	Less adaptation level due to predefined settings.	Medium adaptation level.	Higher adaptation and higher accuracy.

Table 2.18: Feedback classification according to adaptation possibilities (Self composed)

Among these feedback adaptation classification types, adaptive feedback seems to be the most effective feedback type due to its adaptability of feedback settings.

2.5. Feedback Adaptation

Feedback adaptation can be done individually or group wise. Only the individual feedback adaptation will be considered in the scope of the proposed solution.

2.5.1. Individual Feedback Adaptation

2.5.1.1. Critical Evaluation of User Models

The adaptation of feedback to the user's individual characteristics is traditionally organized on the base of a user model (Kobsa and Wahlster, 1989; Kobsa, 1993). A user model determines the user's tasks, goals, characteristics, and beliefs which are important for feedback adaptation.

2.5.1.1.1. Felder Silverman Learning Style Model

There are four dimensions in FSLSM as shown in figure 2.3. Each learner is categorized by a specific preference for each of these dimensions. FSLSM is based on the tendencies, showing that learners with a high preference for certain behavior can also act sometimes differently.

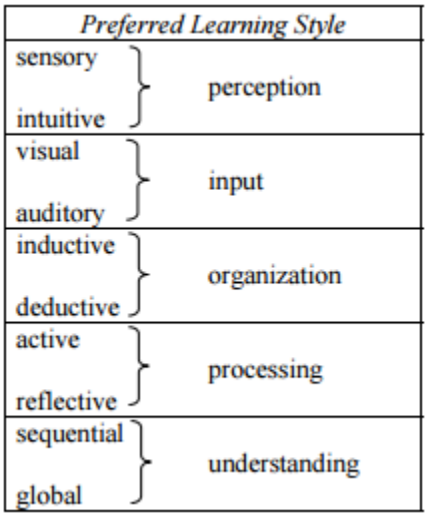

Figure 2.3: Four dimensions of FSLSM (Silverman, 1988)

2.5.1.1.2. Kolb Learning Style Model

There are four categories of learning styles in KLSM. They are Converging/Convergent, Diverging/Divergent, Assimilating and Accommodating. The learning cycle is also divided into 2 aspects as Knowing and Understanding or "Transforming" Knowledge.

	Reflective Observation (Watching)	Active Experiment (Doing)
Concrete Experience	Diverging/Divergent (Team)	Accommodating (Team)
Abstract Conceptualization	Assimilating (Solo)	Converging/Convergent (solo)

Figure 2.4: Transforming knowledge (Kolb, 1984)

2.5.1.1.3. Honey and Mumford Learning Style Model

Honey and Mumford Learning Style Model, based upon the work of Kolb, and they identified four distinct learning styles or preferences as:

- Theorist
- Activist
- Pragmatist
- Reflector.

These are the learning methodologies that individuals naturally prefer and they recommend that in order to maximize one's own personal learning each learner must:

- Understand their learning style (Mobbs, 2003)
- Seek out opportunities to learn using that style (Mobbs, 2003)

2.5.1.1.4. Summary of Feedback Personalization Models

Each of the above LSM describes different classifications considering different aspects. FSLSM describe the learning style of an individual in more detail distinguishing between preferences on four dimensions. But other models classify learners into a few groups. Another main difference is that FSLSM is based on the tendencies, indicating that learners with a favouration for certain behavior can also act sometimes differently. According to Carver et al. (1999), “the Felder Model is most appropriate for hypermedia courseware”. Kuljis and Liu (2005) confirmed this by doing a comparison of learning style models with respect to the application in e-learning and web-based learning systems. So that FSLSM can be suggested as the best Learner model to be used when personalizing feedback.

According to Brusilovsky feedback can be adapted to the following characteristics of a user: background and experience, knowledge, goals, interests, individual traits, preferences and environment.

Besides the parameters, which are usually included in the learner model that are listed above, the following groups of individual user characteristics are important for the adaptation of e-learning systems:

Characteristic	How it is used
Personal data	This includes demographic characteristics such age, data, culture, etc.

	The use of personal data is to give a personal effect to the application. Example: "Sorry, this answer is incorrect, Ershadi. You should retry".
Knowledge	The user's answers to a test provide information related to the user's knowledge. The feedback to an answer can be more informative when it refers to knowledge the learner already has, possibly about related topics.
Interaction Parameters	For feedback adaptation, the following interaction parameters can be taken into consideration: (i) Chronometric data: Time spent viewing pages with LM, time spent in passing the question and the total time spent on the assignment, idle interval times. (ii) Try data: The number of attempts to pass the assignment, the number of times needed to give the correct answer for the certain question. (iii) Navigation data: Visited sites and content, number of visits, the frequency that specific selections have been made.

Table 2.19: Feedback personalization characteristics (Self composed)

2.5.2. Critical evaluation of Feedback Adaptation Frameworks with LMR

2.5.2.1. Self-Directed E-Learning Material Recommendation System with Online Evaluation

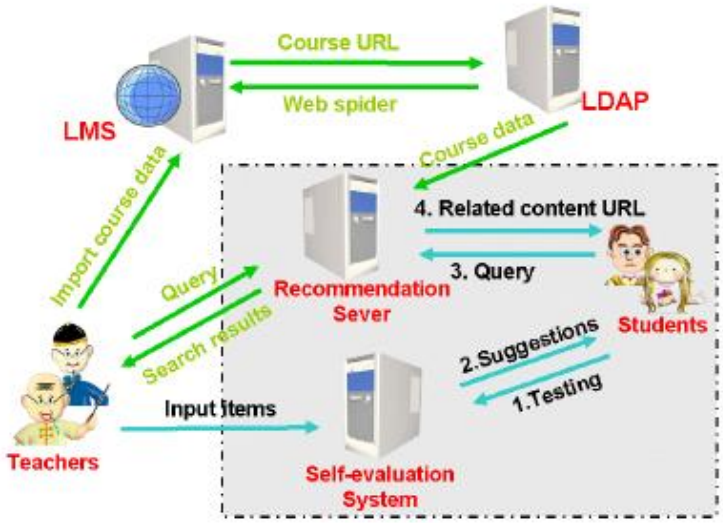

Figure 2.5: System architecture (Liu and Feng-Jung, 2008)

Introduction	An ontology-based self-evaluation system with material recommendation system. The system is divided into 2 subsystems: Material recommendation subsystem and self-evaluation subsystem.

	In this material recommendation part, the system recommended the related content by analyzing previous learners' activities (Liu and Feng-Jung, 2008).
Limitations	Does not match with user knowledge. Only matched with user preferences and keywords
Future Work	The system prototype has been established, but not completed. So far, there are 28 URLs of courses registered in the recommendation system respectively. It contains about 574-course units in total. Each query request spends about 0.65 seconds (Liu and Feng-Jung, 2008).

Table 2.20: Self-directed e-Learning material recommendation system with on-line evaluation

2.5.2.2. Hybrid Attribute-Based Recommender System for Learning Material Using Genetic Algorithm and a Multidimensional Information Model

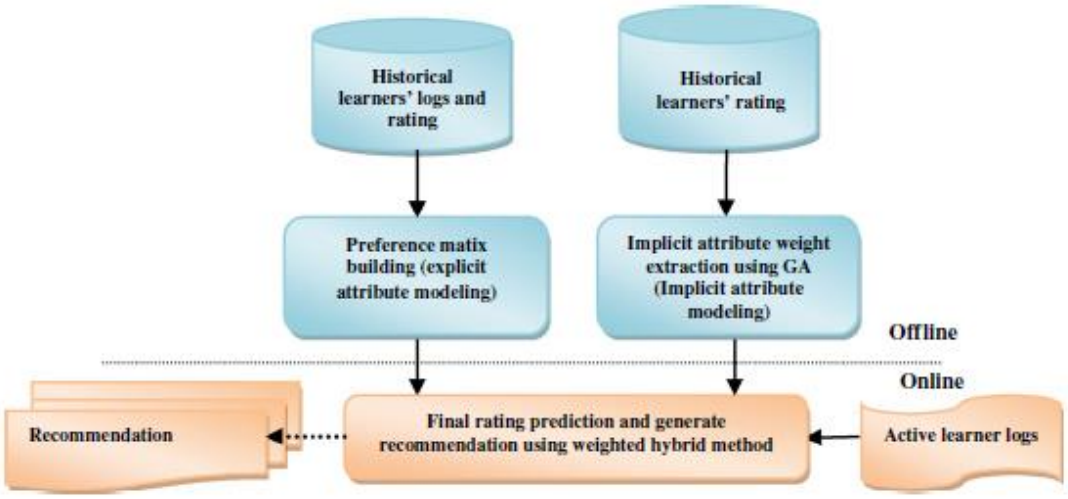

Figure 2.6: System framework of Hybrid attribute-based recommender system for learning material using genetic algorithm and a multidimensional information model

Introduction	Contains 2 main modules: **Explicit attribute based recommender** - Weights of implicit or latent attributes of materials for learner are considered as chromosomes in genetic algorithm then this algorithm optimizes the weights by historical rating. Then, recommendation is generated by NNA using the optimized weight vectors implicit attributes. **Implicit attributes based recommender** - PM is introduced that can model the interests of the learner based on explicit attributes of LM in a multidimensional information model. Then, a new similarity measure between PMs is introduced and recommendations are generated by NNA (Salehi et al., 2013).
Limitations	Does not match with user knowledge. Only matched with user ratings and the topic.

Future Work	Improve the recommendation process by hybrid approach and mine learners' historical access records for discovering the resource access sequential patterns. Then, using these sequential patterns, we can predict the most probable resource that a learner will access in the near feature (Salehi et al., 2013).

Table 2.21: Hybrid attribute-based recommender system for learning material using genetic algorithm and a multidimensional information model

2.5.2.3. Automatic Recommendations for E-Learning Personalization Based on Web Usage Mining Techniques and Information Retrieval

Introduction	Recommended learning resources are computed based on the current learner's recent navigation history, as well as exploiting similarities and dissimilarities among learners' preferences and educational content. This contains 2 modules: **Off-line module** - Preprocesses data to build learner and content models. **Online module** - Uses these models on-the-fly to recognize the students' needs and goals, and predict a recommendation list. Recommended learning objects are obtained by using a range of recommendation strategies based mainly on content-based filtering and collaborative filtering approaches, each applied separately or in combination (Khribi et al., 2013).
Limitations	User Interaction parameters have not considered while generating feedback. Have considered user preferences and knowledge.
Future Work	Integrating educational preferences in the learner's model such as learning styles, media types, etc. The learner's model to should compose of three main components: learner's profile, learner's knowledge and learner's educational preferences (Khribi et al., 2013).

Table 2.22: Automatic recommendations for e-learning personalization based on web usage mining techniques and information retrieval

2.5.2.4. Comparing Features and Considered User Characteristics of Existing Feedback Adaptation Frameworks

As mentioned in the above table 2.22, there are 3 main previous work identified and the feedback generated by those projects/products are generated considering the following user characteristics as shown below table 2.23.

Considered Factors to recommend learning material and generate feedback

C1. User history
C2. Topic
C3. User preferences
C4. Background and experience
C5. Knowledge of the subject being studied
C6. Score
C7. Interaction parameters

C8. Try data, such as the number of mistakes the user makes during the testing, the number of times needed to give the correct answer for the certain question

C9. Navigation data, such as visited links and pages, number of visits, the frequency that specific selections have been made

C10. Chronometric data

Name and owner	**Considered user characteristics**	**Considered common characteristics**
Self-directed e-Learning Material Recommendation System with On-line Evaluation	C1, C2	C1
Hybrid attribute-based recommender system for learning material using genetic algorithm and a multidimensional information model	C1, C3	C1, C3
Automatic Recommendations for E-Learning Personalization Based on Web Usage Mining Techniques and Information Retrieval	C1, C3, C7	C1, C3, C7
Proposed solution	C1, C2, C3, C4, C5, C6, C7, C8, C9, C10	C1, C3, C7

Table 2.23: Existing feedback adaptation technologies (Self composed)

As displayed from table 2.23, none of the frameworks identified, contained all the features supported by elaborated feedback system proposed in the solution and they lack the knowledge mapping with recommendations.

2.6. Measuring Student Knowledge

All the above mentioned products lack the relationship between the knowledge and the LMR. When recommending LM although the knowledge gap filling is used widely they consider only about the keywords while providing recommendations. But when providing recommendations, identifying the keywords of the knowledge gap is not enough. For an example, there can be 2 students who lacks Java Inheritance knowledge, if the keyword is identified as inheritance and provide recommendations to both students, although the student knowledge is different when compared their marks of the questions belonging to inheritance, the recommendations are not going to be accurate. Their knowledge level should be compared when providing recommendations. Not only the level, students learning preferences with the history should also be considered. The solution will provide a novel way of breaking down students' knowledge into different areas and provide better recommendations by using the knowledge topics and the sub topics, thus a valid conclusion can be made that the proposed solution is solving the problem in a novel and unique approach.

2.7. Recommending Learning Material

2.7.1. Critical Evaluation of Recommendation Techniques

There are lot of recommendation techniques found in recent days and some of the techniques are hybrid, which they have formed combining 2 or more in order to reduce the drawbacks of each technique.

2.7.1.1. Collaborative Filtering

Collaborative filtering Shang et al (2014) also referred to as social filtering, tries to recommend items for a particular user by considering the recommendations given to items by other users with similar preferences. In this approach the recommender system would first try to understand the preferences of a particular user and then cluster users or items into similar preference groups. A recommendation process would be carried out based on the ratings given by the group on a particular item.

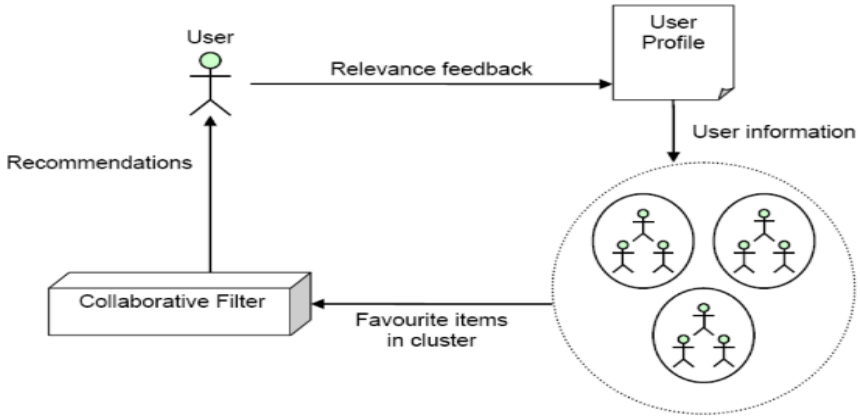

Figure 2.7: Architecture of collaborative recommender systems (Hahsler, 2011)

Advantages	Disadvantages
• No need of domain knowledge • Adaptive: Improves in quality with time.	• Cold start problem • Sparsity problem • Insensitive to preference changes

Table 2.24: Advantages and disadvantages of collaborative filtering

2.7.1.1.1. Collaborative Filtering Approaches

Collaborative filtering has 2 main approaches. Below table provides an evaluation on the impact those methods would have on the accuracy of the system.

Approach	Description	Impact on accuracy

Memory based	This approach makes use of user rating data to compute the similarity between users or items. This is used for making recommendations. This is effective and easy to implement.	As the raw data is kept in the memory and processed these approaches would reflect the latest ratings for an item or user which would make the recommendations more accurate.
Model based	Models are developed using data mining, machine learning algorithms to find patterns based on training data. These are used to make predictions for real data.	As the raw data is processed offline those may not reflect the latest rating for an item or user leading to lower accuracy.

Table 2.25: Collaborative filtering approaches (Self composed)

The choice of choosing between these two approaches will be a tradeoff decision that has to be taken by considering the accuracy requirement and the level of users and items the system would have to manage. According to Gupta et al (2013) most social networks use memory based approaches for the recommendations due to the vast amount of items and users that have to deal with. But for a feedback recommender system with a comparatively smaller number of users and items it's not advisable to select memory based approaches due to the large investments that had to be incurred on the hardware.

2.7.1.1.2. Model-Based Collaborative Filtering Approaches

The model building process is performed by different machine learning algorithms such as Bayesian network, clustering, and rule-based approaches.

- Bayesian model formulates a probabilistic model for collaborative filtering.
- Clustering model treats collaborative filtering as a classification and cluster similar users in the same class and estimates the probability that a particular user is in a particular class, and from there computes the conditional probability of ratings.
- Rule-based approach applies association rule discovery algorithms to find the association between co-purchased items and then generates item recommendation based on the strength of the association between items.

These approaches are described and analyzed more in the section 2.7.1.2.3 and it has been suggested that the k-means clustering is the most suitable approach.

2.7.1.1.3. Algorithms to Measure User Similarity

Algorithm	K-nearest neighbor

Description	In k-NN, the output is a class membership. An object is classified by a majority vote of its neighbors, with the object being assigned to the class most common among its k nearest neighbors. If k = 1, then the object is simply assigned to the class of that single nearest neighbor.
Advantages	**Disadvantages**
• Robust to noisy training data	• High computation cost

Table 2.26: K-nearest neighbor (Self composed)

Algorithm	Pearson Correlation
Description	This is a measure of the linear correlation between two variables X and Y, giving a value between +1 and −1 inclusive, where 1 is total positive correlation, 0 is no correlation, and −1 is total negative correlation.
Advantages	**Disadvantages**
• Match critics with similar tastes, even though their actual ratings might be far apart.	• This is not as intuitive as the Euclidean distance measure. • Slower in to determining. • Cannot measure correlation accurately.

Table 2.27: Pearson correlation (Self composed)

In k-NN the computation cost is high since it needs to compute the distance of each and every query instances to all the training samples. But it is robust to noisy training data than the Pearson Correlation. This concludes that the k-NN is the most suitable algorithm to measure user similarity.

2.7.1.2. Content Based Recommendations

The content-based recommendations suggest similar items to users based on similarities between the content of the items and a user profile (Van Meteren and Van Someren, 2000). The content of an item is characterized as a set of terms known as descriptors which describes the nature of the item and the user profile contains information about the content of the items of which the user has previously shown an interest based on a weighted vector of item features.

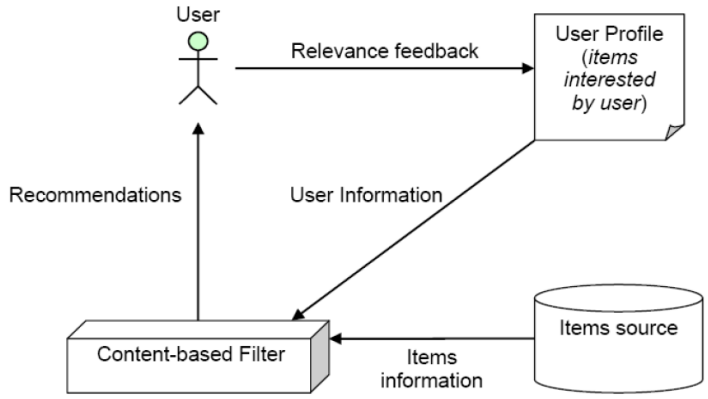

Figure 2.8: Architecture content-based recommender systems - (Adomavicius, G and Tuzhilin, A., 2005)

2.7.1.2.1. Advantages and Limitations of Content Based Recommendation Systems

Advantage & description	**Impact on accuracy**
User independence - Content-based recommender systems have the capability of building a user profile solely based on the feedback provided by an active user.	This wouldn't have a major negative impact on the accuracy as the accuracy of the recommendations would only be restricted to the gathered knowledge. But the system would not be able to recommend any items in a different category to the user.
Transparency – Content-based recommender systems can provide explanations for the recommended items by listing content descriptions that caused an item to be recommended.	The feedback of a selection can easily be mapped to better understand the preferences of a user which will be helpful to carry out more accurate recommendations.
Recommending of unseen items to users – Content-based recommender systems have the capability of recommending items of the preferred category which are not yet rated by any user.	This advantage would make the system more dynamic as it can make more alignments between users and items which will improve the accuracy.

Table 2.28: Advantages and limitations of content based recommendation systems (Self composed)

2.7.1.2.2. Item Descriptor Assignment Approaches

delOlmo and Gaudioso (2008) have identified two approaches that can be used to assign descriptors to an item and below tables provide an overview of those two approaches along with the impact each would have on the proposed solution.

Approach	Automated descriptor assignment

Description	The system would try to assign descriptors to an item using automated processes like NLP or ontology alignment.
Advantages	**Disadvantages**
• Higher accuracy rate compared to manual descriptor assignment approach.	• Additional software modules are needed to read and extract the correct item descriptors. • High coupling with 3rd party environments. • Require more time to assign descriptors.
Impact	The accuracy will be increased if an automated approach like NLP or ontology alignment is used, but the development time will increase since the NLP is a complete new area for the developer.

Table 2.29: Automated descriptor assignment approach (Self composed)

Approach	Manual descriptor assignment
Description	In this approach the entity who would add the item to the item repository
Advantages	**Disadvantages**
• Ease to develop and maintain the system. • Comparatively it would require less time to assign descriptors.	• May reduce the user friendliness of the system. • Lower accuracy rate
Impact	It would be hard to identify possible polysemy, synonymy, and multi-word representations to a higher degree and it will have a negative impact on the accuracy of the system.

Table 2.30: Manual descriptor assignment approach (Self composed)

It can be concluded from the above comparison that the automatic descriptor assignment has a high accuracy rate.

2.7.1.2.3. Machine Learning Approaches

The machine learning techniques such as Bayesian Classifiers, cluster analysis, and decision trees, are used in order to estimate the probability that the user is going to like the item.

Approach	Bayesian Classifiers
Advantages	**Disadvantages**
• Simple • Need less training data	• Can’t learn interactions between features

Impact	Since it needs a lesser amount of training data, time taken for creating the dataset will be less and since it has proven a high accuracy rate in complex real world situations a high accuracy can be expected.

Table 2.31: Bayesian classifiers (Self composed)

Approach	Cluster analysis
Description	Cluster analysis can be done via analyzing clustering algorithms.
Algorithm	**Impact on accuracy**
K-means	• The lowest initial accuracy rate provided in classification, but since the algorithm follows an iterative process the quality of the grouping can be improved as time goes on • More dynamic clustering approach
Hierarchical clustering	• As the number of clusters increase the accuracy of the classification increases • Since the algorithm doesn't support an iterative process change in the patterns of items cannot be absorbed.
Expectation maximization map	• Provides a higher accuracy rate compared to K-means algorithm, but as the cluster number increase the accuracy of the grouping decreases
Self-organization map	• Shows the highest accuracy in classifying most objects into their suitable clusters • As the number of clusters increase the accuracy of the clustering decreases • Less sensitive to noise of the data set
Summary	When evaluating the above mentioned clustering algorithms, it can be suggested that K-means clustering technique as the most suitable clustering technique for the proposed system due to scalability and dynamic nature in understanding pattern changes. When considering the expectation maximization clustering approach, though in accuracy it is similar to K-means it can't be suggested due to lower capability to work with larger data sets compared to the K-means algorithm.

Table 2.32: Cluster analysis (Self composed)

Approach	Decision trees
Advantages	**Disadvantages**
• Simple to understand and interpret. • Allow the addition of new possible scenarios	• Calculations can get very complex, mostly if many values are uncertain and many outcomes are linked.

• Help determine worst, best and expected values for different scenarios	
Impact	For data including categorical variables with different number of levels, information gain in decision trees are biased in favor of those attributes with more levels there is a negative impact on accuracy (Wikipedia, 2016).

Table 2.33: Decision trees (Self composed)

After considering the impact for the proposed solution cluster analysis with K-means clustering can be suggested as the most appropriate machine learning technique to use in content based filtering.

2.7.1.3. Knowledge Based Approach

Limitation & description	Impact on accuracy
Limited content analysis – Irrespective whether an automated or manual process is used to assign descriptors to an item content-based recommender system have a native limitation in the number and the types of descriptors that can be used to describe an item.	Since the accuracy of content based recommendation systems is depended on a successful matching between the item descriptors and user profile this limitation will have a negative impact on the accuracy of the system.
Over specialization – This limitation will make items that are going to be recommended to a user will be similar to those already seen thus making the recommendations to the limited extent of novelty.	This will not have a major impact on the accuracy of the prediction and only be a limitation in recommending hot items from different categories to a user.
Cold starter problem of a new user – A new user will need to rate sufficient number of items for the system to gauge the preferences accurately to provide reliable recommendations.	This will have a negative impact on the accuracy of the recommendations done for a new user, which may even lead to new users not trusting the system.
Grey sheep – When the preferences of a user are changed collaborative recommender systems would take time in adjusting to the new preferences of the user.	This will have a negative impact on the accuracy for a while until the system understand the new preferences of the user.

Table 2.34: Knowledge based approach

Knowledge based approach uses knowledge about users and products to pursue a knowledge-based approach to generating a recommendation, reasoning about what products meet the user's requirements (Burke, 2000). Knowledge-based approaches are distinguished in that they have functional knowledge: they have knowledge

about how a particular item meets a particular user need, and can therefore reason about the relationship between a need and a possible recommendation (Burke, 2002).

Advantages	Disadvantages
• Sensitive to preference change • Does not need to be initialized with a database of user preferences • Can include non-product features	• Knowledge acquisition

Table 2.35: Advantages and disadvantages of knowledge base approach

2.7.1.4. Hybrid Recommendation Techniques

Since both CBF and CF systems independently provide lower recommendation accuracies due to the inherent limitations of the two approaches, hybrid recommendation systems have gained popularity in the recent past. The key inspiration behind a hybrid recommendation system is to combine at least two recommendation engines to negate the limitations of one with the other. Felfernig and Burke (2008) and Adomavicius and Tuzhilin (2005) have demonstrated that combining multiple techniques together would achieve some synergy between the techniques used and as a result would try to provide more accurate recommendations than pure approaches.

Hybridization method	Description
Weighted	The scores (or votes) of several recommendation techniques are combined together to produce a single recommendation.
Switching	The system switches between recommendation techniques depending on the current situation.
Mixed	Recommendations from several different recommenders are presented at the same time
Feature combination	Features from different recommendation data sources are thrown together into a single recommendation algorithm.
Cascade	One recommender refines the recommendations given by another.
Feature augmentation	Output from one technique is used as an input feature to another.
Meta-level	The model learned by one recommender is used as input to another.

Table 2.36: Hybrid recommendation techniques (Burke, 2002)

2.7.1.5. Summary of Recommendation Techniques

A hybrid recommendation technique will have less disadvantages and more advantages depending on the domain addressed by the proposed solution, but it can be suggested that the meta-level hybridization method is more

suitable for the proposed solution as one recommendation method can use the trained data from the other recommendation approach. This will be discussed more in the section 5.3.4.

2.8. Chapter Summary

This chapter mainly focused on finding the best approaches, concepts and techniques to provide a solution to the problem domain by reviewing current online assessment feedback techniques. The chapter started by evaluating the e-learning approaches and suggested that the content personalization is the best e-learning approach since it makes more impact on a learner to improve the knowledge. Then the e-learning techniques were evaluated, and suggested that online assessments and quizzes have more impact on improving learner's knowledge. Next the online assessments were evaluated by means of techniques and technologies. From the evaluation, that the automated assessments should be created using Moodle was suggested. Afterwards the feedback provided in an assessment was evaluated. First the feedback concepts were considered and suggested that the feedback triad is the best feedback concept and secondly feedback classification types were evaluated. Suggested that the adaptive feedback should be generated considering other classification types of feedback depending on the user characteristics. Since only the individual feedback adaptation is considered in the scope of the proposed solution, user models used to adapt feedback was evaluated. The FSLSM was suggested as the best user model, but with that there were also some other characteristics of users which should be considered while feedback personalization. Then the existing feedback adaptation frameworks were evaluated and found out that none of them provide a complete solution for the existing problem. Finally, the recommendation techniques which can be used to recommend learning material were evaluated and suggested to use feature augmentation hybrid approach of recommending based on content based filtering and collaborative filtering approaches. From the literature survey conducted, the advantages and disadvantages of different techniques, approaches and algorithms were critically evaluated. The best approaches were found through analyzing the advantages, disadvantages and based on the technical relativity and the impact to the proposed solution.

Elaborated Feedback Generator

Chapter 3: Project Management

- Chapter Overview
- Project Management Methodology
- Development Methodology
- Research Methodology
- Chapter Summary

3.1. Chapter Overview

This chapter includes the project management procedure followed during the project. Project management procedure will start from identifying an appropriate project management methodology and then discusses the time and resource allocations of the project. Possible risks are also identified with the suitable mitigation plans, making a discussion about selecting the proper software development methodology for the project.

3.2. Project Management Methodology

Every project has its constraints such as scope, time and cost. It is essential to manage those constraints accurately in order to produce a quality output from the project. When compared to an industry project, it is hard to maintain these constraints in a research project due to numerous requirement variations, which verifies the importance of a suitable project management methodology. PRINCE2 is a commonly used project management methodology comprised of the high-level management, control, and organization of a project.

PRINCE2 is a process-based method for effective project management. This is based on seven themes and it was decided to use PRINCE2 as the project management methodology due to the previous exposure and experience.

3.2.1. Time Allocation

Following table 3.1 represents a summary of the identified main tasks of the project. Research projects require the literature review process to be carried till the end of testing phase due to frequent requirement variations although the draft submission due early. Subsequently, the documentation of the project will spread throughout the project lifetime as it will be the final deliverable of the project.

Week Commencing	Date	Event
28 Sept ‘15	02/10/15	Submission of Draft Terms of Reference
05 Oct ‘15	05/10/15	Evaluation of Draft Terms of Reference
05 Oct ‘15	09/10/15	Submission of Final Terms of Reference (TOR)
19 Oct ‘15	23/10/15	Submission of Literature Review
16 Nov ‘15	20/11/15	Submission of Requirement Specification
21 Jan ‘16	27/01/16	Submission of Interim Report
15 Feb ‘16	19/02/16	Demonstration of Prototype and submission of report on prototype
28 Mar ‘16	01/04/16	Submission of Draft Project Reports
18 Apr ‘16	22/04/16	Submission of Bound copies of the Project Reports

Table 3.1: Submission dates

3.2.2. Constraints and Dependencies

The successful completion of the project will depend on the following constraints and dependencies.

- Time constraint - Considered as a major challenge for the successful completion of the project as the whole software development life cycle has to be carried individually.
- Lack of prior knowledge – Due to lack of knowledge on feedback recommender systems with learning material recommendations and software agents, the development of the proposed system may be hindered.

3.2.3. Potential Risks and Mitigation Plan

Risk Id 1	**Failure to keep with the up-to-date domain knowledge & technology changes**		
Risk level	High	**Occurrence Frequency**	High
Description	Elaborated feedback systems with recommending LM is a very active research area where new ideas and concepts are brought forward on a regular basis, making it difficult to keep up with the most up to date knowledge of the domain. It has to be accepted that the surrounding technologies too may change over the course of the project time schedule. This will present a risk that the system is not being developed using the most up to date domain knowledge nor using the latest technologies.		
Mitigation	• Check for any new work done on the domain area on a weekly basis. • Check for technology changes on a weekly basis. • Keep frequent communication with domain experts about the latest developments.		
Risk Id 2	**Constant, and repeated changes to requirements**		
Risk level	High	**Occurrence Frequency**	High
Description	As the nature of a research project, there would be constant changes to the requirements in every phase of the software life cycle. This is considered as a risky project as it may be difficult to manage all the requirement changes within the allocated time period.		
Mitigation	• Prepare ahead for the changes. • Prioritize the changes and try to tackle only the critical changes.		
Risk Id 3	**Not being able to achieve the expected accuracy level for the recommendations**		
Risk level	High	**Occurrence Frequency**	Low

Description	Due to time constraints and changes to requirements and technologies, the developed system may not be able to achieve the expected accuracy rates for its users.		
Mitigation	• Try to keep up with the latest developments • Finish the prototype early to have enough time to make changes if required.		
Risk Id 4	**Data lost due to hardware, software and system failures**		
Risk level	High	**Occurrence Frequency**	Low
Description	During the course of the project, the data of the project can get lost due to hardware, software and system failures and it may prove to be a critical threat to the successful completion of the project.		
Mitigation	• Maintain daily backups & carry out continuous testing and debugging of the software.		

Table 3.2: Identified risks for Elaborated Feedback Generator system (Self composed)

3.3. Development Methodology

In order to avoid schedule and cost overruns and to mitigate frequent requirement changes of the project, an appropriate development methodology should be selected. With the aim of identifying a suitable development methodology, key characteristics of several software development methodologies were critically evaluated. Below table 3.3 shows the characteristics of several frequently used software development methodologies and the following evaluation is based on the available resources, the nature of the project and ability to meet the identified requirements.

	Software development methodologies				
	Waterfall methodology	**Rapid application methodology**	**Spiral methodology**	**Agile methodology**	**Prototype development methodology**
Characteristics	All the requirement should be known in the upper hand.	Reduce the development time and increases reusability of components.	Continued refinement of the final software product.	Iterative and incremental development Agility for rapidly changing.	The prototype is developed on currently known requirements.
	Heavy documentation.	Iterative development.	Emphasize risk analysis.	Customer interaction.	Higher rate on customer interaction

	Rigid and linear	Software prototyping.	Iterative & incremental.	Accelerated delivery.	

Table 3.3: Characteristics of software development methodologies (Self composed)

The Spiral methodology supports continuity of cycles of the software development life cycle without clear termination of conditions which would help to counter frequent requirement fluctuations which would lead to timely delivery of the prototype. Additionally, the Spiral methodology helps to analyze the risks that would affect the final product and finding those risks in advance can lead to speed up the development process. As the major challenges of the project in hand, are the time constraint and frequent requirement fluctuations it can be concluded that Spiral methodology would be the most suitable development methodology. More details on the other methodologies are described in Appendix C.

3.4. Research Methodology

A research can be categorized into two categories known as inductive researching and deductive researching. Deductive approach is aimed at proving and testing a hypothesis while the inductive approach is concerned with the generation of new theory emerging from the data. The project in hand falls into the deductive researching approach as the aim of the project is to prove and test that an elaborated feedback system with recommending learning material can solve the limitations mentioned in the first chapter.

3.5. Chapter Summary

This chapter highlighted the importance of a suitable project management methodology to get the best result out of the project and PRINCE2 which is a widely used project management methodology was selected as the suitable project management methodology due to the previous understanding and exposure to it. Next the whole project was broken down into different tasks and proper time allocation was done, so that the tasks can be done accordingly and parallel. Then the identified constraints of the research and possible risks that can occur during the course of the project were recognized and the mitigation plans were discussed. After that, several development methodologies were evaluated to identify a suitable development methodology for the project and it was decided to adopt to the Spiral development methodology due to its flexibility to support frequent requirement changes that can occur during the project life cycle. Finally, this chapter discussed choosing a research methodology that has to be adopted for the successful completion of the project and deductive research methodology was adopted over inductive methodology due to the reason that this project was based on proving the hypothesis of Elaborated Feedback Generator with learning material recommendations.

Elaborated Feedback Generator

Chapter 4: Requirements Specification

- Chapter Overview
- Stakeholder Analysis
- Requirements Elicitation Techniques
- Scope Refinement
- Chapter Summary

4.1. Chapter Overview

This chapter is to identify the stakeholders of the proposed solution, to get a valid input from them using the identified best elicitation techniques and to identify the functional and non-functional requirements. The stakeholder analysis, identify elicitation techniques, executing elicitation techniques and scope refinement through identifying use cases, functional and non-functional requirements are described in this chapter. The main objective of this chapter is to incorporate stakeholders into the project development phase ensuring successful knowledge transfer as well as enabling stakeholder communication with the feedback, so that the chance of stakeholder acceptance level of the final product deliverable will increase.

4.2. Stakeholder Analysis

4.2.1. Stakeholder Roles

4.2.1.1. Beneficiary

4.2.1.1.1. Functional Beneficiary

Stakeholder:	**Viewpoint:**
Learners	Able to do assessments easily and to view feedback with the learning material recommendations for the future growth.
Instructors	Do not need to waste time marking the assessments and giving feedback.
Educational institutes	Easier to manage the assessment procedure than conducting it manually.

Table 4.1: Functional beneficiary (Self composed)

4.2.1.1.2. Financial Beneficiary

Stakeholder:	**Viewpoint:**
Instructors	Will get an income when a learner is registered with a course/assessment.
Educational institutes	Will get an income when a learner is registered with a course/assessment.
Developer	Want to develop a bug free system which meets the requirements. Developer gets paid when he develops the elaborated feedback generating system.
Sponsor	Sponsors get a percentage of the total profit earned from the elaborated feedback generating system.
Contracting parties	Contracting parties also get an income based on the service that they provided.
Project Manager	Wants to manage the constraints to assure smooth flow of the project

Table 4.2: Financial beneficiary (Self composed)

4.2.1.2. Negative

Stakeholder:	Viewpoint:
Competitors	Similar systems will have threat to their business. Would want to identify drawbacks of the system and implement a better solution.
Assessment markers	The need of assessment keepers for the educational institutes will be reduced. So that they will have a threat to their jobs.
Hackers	Hack the system and make it unresponsive. Make attacks to the system and may grab assessment data, etc.

Table 4.3: Negative stakeholders (Self composed)

4.2.1.3. Operational Role

4.2.1.3.1. Human Operators

4.2.1.3.1.1. Normal

Stakeholder:	Viewpoint:
Learners	Do online assessments and view feedback with learning material recommendations.
Instructors	Create assessments.

Table 4.4: Normal stakeholders (Self composed)

4.2.1.3.1.2. Maintenance

Stakeholder:	Viewpoint:
Developer Maintenance	Easy maintainability of the system.

Table 4.5: Maintenance stakeholders (Self composed)

4.2.1.4. Expert

4.2.1.4.1. Safety Opinion

Stakeholder:	Viewpoint:
System Security Professionals	They have the knowledge of where system security may go down and cause attacks.

Table 4.6: Safety Opinion stakeholders (Self composed)

4.2.1.4.2. Usability Opinion

Stakeholder:	Viewpoint:
Public	Not all the public are technical people. So the system should provide a better usability level to the public. To point out the weaknesses of the solution and expect the researcher to correct it.

Table 4.7: Usability opinion stakeholders (Self composed)

4.2.1.4.3. Domain Knowledge

Stakeholder:	**Viewpoint:**
E-learning software domain experts	They have the experience gained from working with many feedback generating systems. To provide expert opinion about the technologies and methodologies used for the project.

Table 4.8: Domain knowledge stakeholders (Self composed)

More stakeholders are mentioned in Appendix D.

4.2.2. Onion Model

Following diagram 4.1 illustrates the onion model of the elaborated feedback generating system with its stakeholder groups. The onion diagram represents the identified stakeholders and their roles in proposed solution and below listed are the pressure points of the diagram:

1. Project Manager should make sure that the system is superior and secure
2. Project manager should make sure that the system is met with required standards and qualities.
3. Developer should make sure that the whole process goes on according to plan and is being able to finish it on time.
4. Project manager should make sure that the system is user friendly.

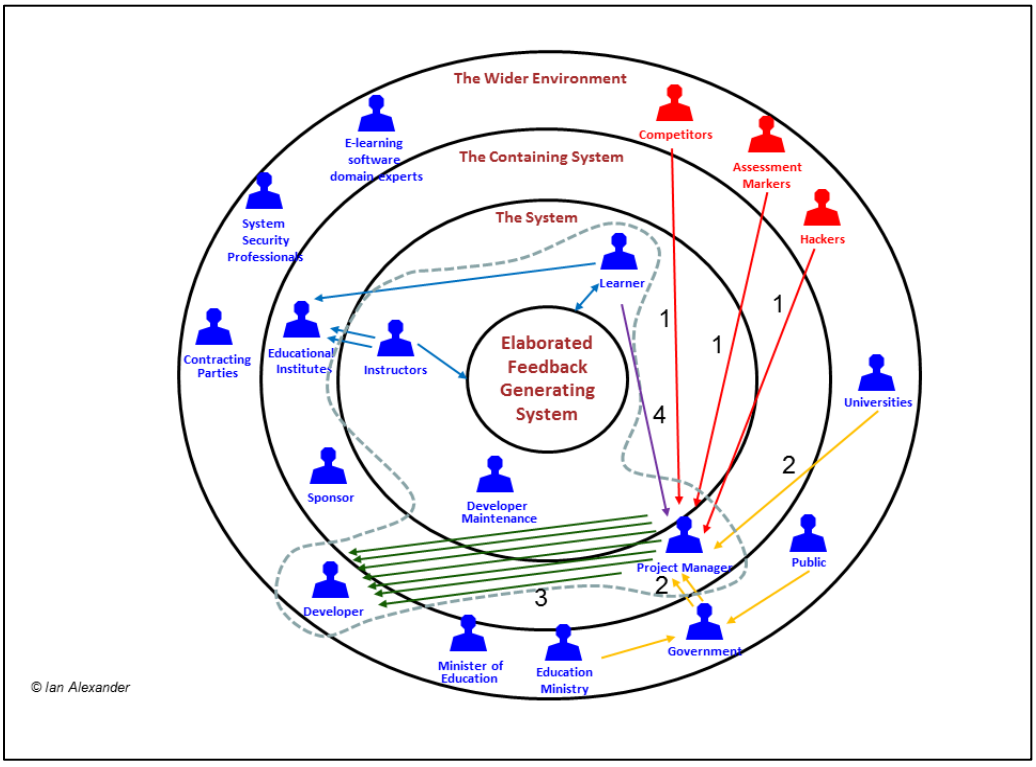

Figure 4.1: Onion model (Self composed)

4.2.3. Context Diagram

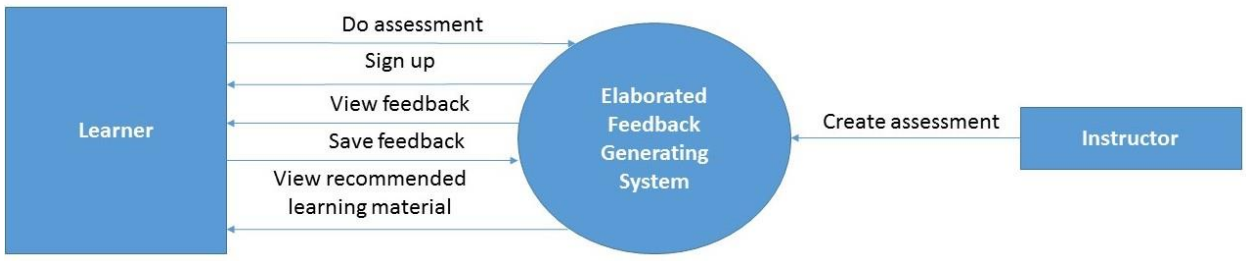

Figure 4.2: Context diagram (Self composed)

4.3. Requirements Elicitation Techniques

Requirements elicitation is to gather information from identified stakeholder groups in order to identify functional and non-functional requirements and to clarify the scope of the proposed solution. There are many requirements elicitation techniques such as brainstorming, document analysis, focus groups, interface analysis, interviews, observation, process modelling, prototyping, requirements workshops and surveys. The requirement gathering for Elaborate Feedback Generator was done using surveys, interviews, literature survey, brainstorming and observation.

Different elicitation techniques were used depending on the stakeholder groups identified in the literature survey phase, to gather the necessary information.

Method No 1	**Literature Review**
The literature review was carried out on the current status and limitations of Elaborated Feedback Generators and various recommender systems, assisted to identify that there has been no proper solution which recommend personalized learning material with feedback.	
Advantages	• Facilitate to identify and better understand crucially evaluated and well documented advantages and limitations concerning Elaborated Feedback Generators. • Paved way to identifying certain areas that were included in the questionnaire and interview process for better clarifications.
Disadvantages	• Due to delays in publications, literature material may not present the latest developments and limitations of the related domains. • Time consuming effort due to the time and effort required to review the vast amount of literature available.

Method No 2	**Questionnaire**
A questionnaire focusing on identifying the end user requirements for an Elaborated Feedback Generator was prepared. Since e-learning systems are used by a large group of users, a soft copy of the questionnaire was made available online.	
Advantages	• Comparatively time saving method to other elicitation methods. • Ability to cover geographically, communality dispersed users. • Ease of tabulation and comparison of the feedback due to the standardization of questions.
Disadvantages	• Success of identifying the correct requirements depends on the honesty of the participants. • May encumber participants from sharing additional information due to standardization of the questions. • Difficulties faced when comprehending answers given to open ended questions.
Executed stakeholder	Among the stakeholder groups, requirement gathering from e-learning students can be easily done via a questionnaire. One of the main reasons is it is necessary to take input from a large group of online students to find out what they expect from e-learning systems and whether they are satisfied with existing solutions.
Method No 3	**Formal interviews**
A series of formal interviews were carried out with the domain expertise of e-learning systems and the instructors/tutors with the aim of identifying standards of elaborated feedback and current processes adapted to categorize LM based on characteristics along with their suggestion for Elaborated Feedback Generators.	
Advantages	• Ease of clarifying doubts with the experts while the interview is going. • Enabling the elicitation of measurable requirements and guideline for the implementation.
Disadvantages	• Inability to reach a wider audience of stakeholders due to the time taken to conduct an interview. • Subjective interpretation of the problem by the experts.

Executed stakeholder	When it comes to stakeholder group of instructors, interviewing them is the best way of gathering requirements, as they might have different requirements based on the experiences they have faced with different e-learning systems.
Method No 4	**Observations of end user operations**
Users accessing online courses were observed to identify the impact of feedback on users and how users differ from each other while following the course.	
Advantages	• Direct insight into the practical limitations faced by users. • Ability to identify new limitations that may not have been identified or ignored by the research experts.
Disadvantages	• Participant behavior may be affected by observer presence.
Executed stakeholder	E-learning users were observed.
Method No 5	**Self-evaluation**
Several self-observation sessions in using e-learning systems were conducted to self-identify the effect of feedback and the characteristics which effect on personalizing a user.	
Advantages	• Direct insight into the practical limitations faced by users. • Ability to identify new limitations that may not have been identified or ignored by the research experts. • Can be used to validate the identified requirements.
Disadvantages	• Certain requirements may be ignored be subjective to self-experiences.

Table 4.9: Evaluation of requirement elicitation methods (Self composed)

4.2.4. Survey/Questionnaire

4.2.4.1. Structure of the Questionnaire

The questionnaire distributed among the potential end users of the system contained questions to identify

- User behavior patterns in an e-learning environment – to gather information as to how end users would be using an e-learning environment

- End user expectations of feedback provided via online assessment systems – to understand end user expectations along with how they would like to imply their preferences to online assessment systems.
- End user expectations from Elaborated Feedback Generator with learning material recommendations – to understand the non-functional expectations of end users when using an online news recommendation system.

The questions of the survey are included in the Appendix E.

4.2.4.2. Limitations of Questionnaire Process

Limitation Id 1	**Limited response**
Though the questionnaire was made available to a larger number of potential end users of different cross sections of the society, not all of the questionnaire were returned back and a substantial amount of the returned were not adequately completed. Therefore, the gathered responses may not represent the absolute view of all the end users.	
Limitation Id 2	**Feedback credibility**
Since the questionnaires were filled by individuals at their own free will, there is no way to authenticate the credibility of the feedbacks given. Therefore, the gathered responses may not represent the absolute view faced by the end users.	

Table 4.10: Limitations of the questionnaire (Self composed)

4.2.4.3. Requirement Elicitation of Questionnaire

The following calculation will show the normal user completion percentage of the survey questionnaire.

$$Successful\ Response\ Rate = \left(\frac{Surveys\ Completed}{Number\ of\ Surveys\ Started}\right) * 100$$

$$Successful\ Response\ Rate = \left(\frac{97}{112}\right) * 100$$

$$Successful\ Response\ Rate = 86.6\%$$

According to the above calculation the successful response rate was above 86% for the normal user questionnaire and with the respondent quantity and percentage it can be concluded that the questionnaire process was successful.

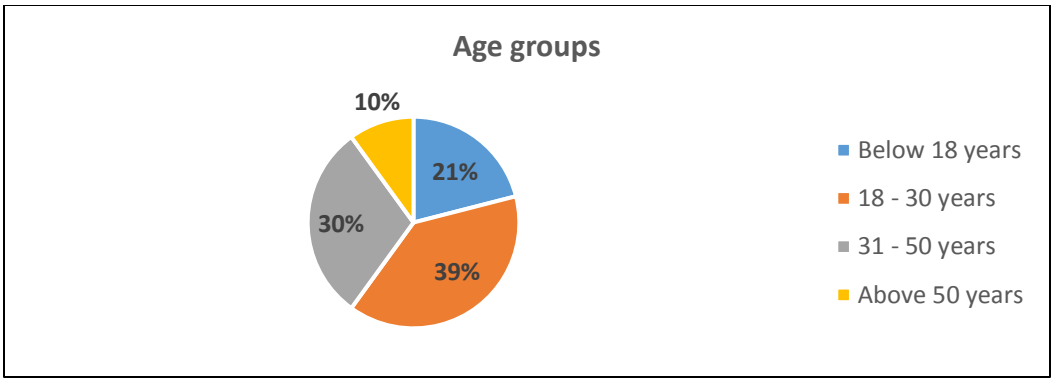

Figure 4.3: Age group representation (Self composed)

These statistics show that the questionnaire has managed to gather requirements from major age groups.

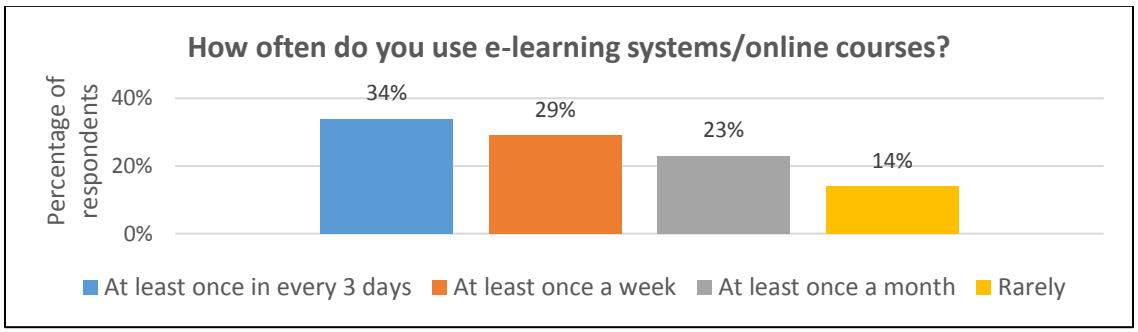

Figure 4.4: E-learning systems access frequency (Self composed)

According to the results shown in above figure 4.4 it can be concluded that the usual e-learning users count is greater than the rare users. Therefore, the results show that the users of the selected domain use e-learning systems more often.

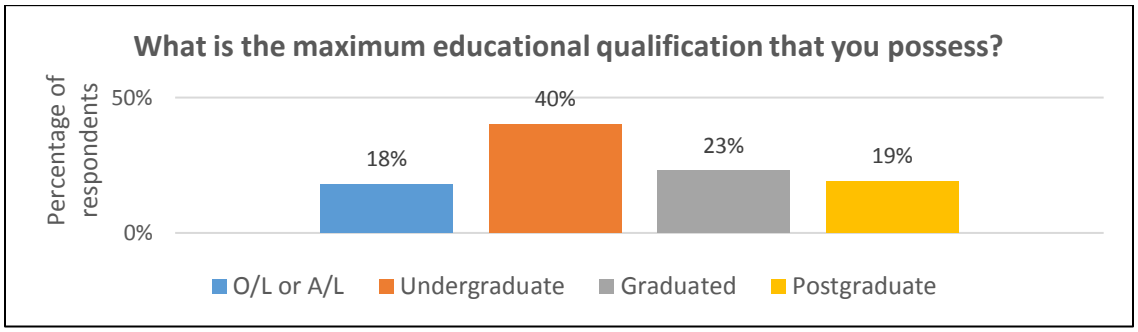

Figure 4.5: E-learning system user qualifications (Self composed)

The above figure 4.5 displays that the majority of e-learning users are undergraduates and graduates.

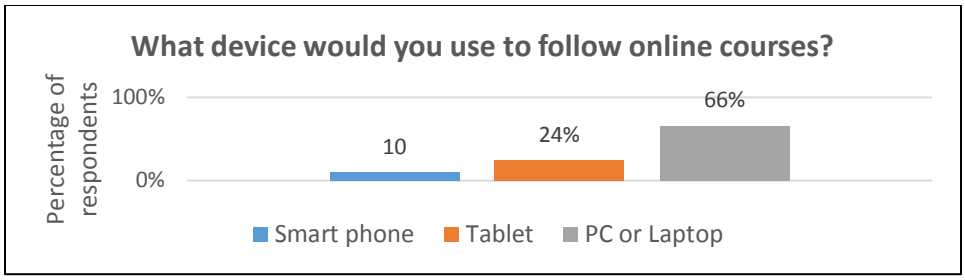

Figure 4.6: Preference of e-learning access (Self composed)

Most users use a PC or Laptop to access e-learning applications rather than a mobile device.

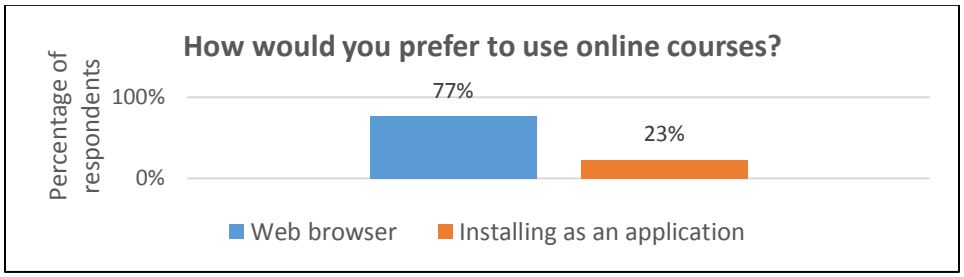

Figure 4.7: Preference of e-learning system access (Self composed)

More than 70% of users prefer to use a web application for e-learning purposes than installing as an application.

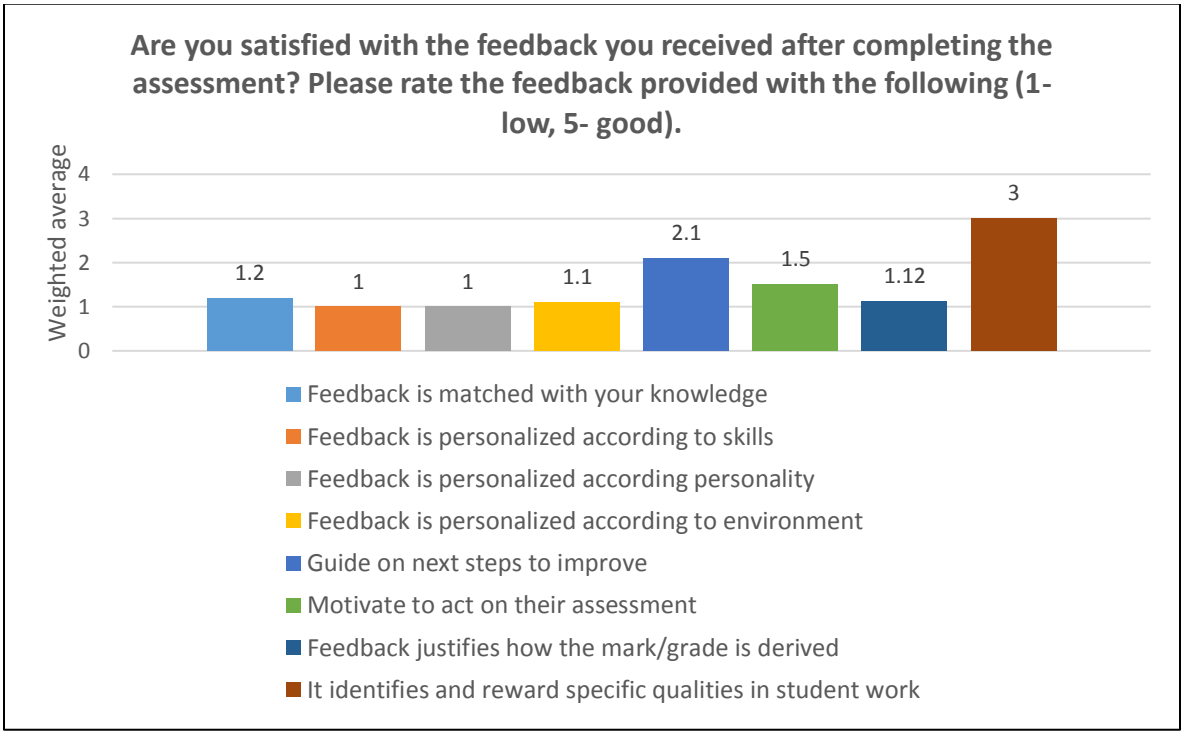

Figure 4.8: Weighted average of features present in e-learning applications (Self composed)

$$Weighted\ Average = \frac{\sum W_x}{\sum W}$$

Here, $\sum W_x$ is the total of rating for a feature and $\sum W$ is the number of respondents. According to above graph it shows that users are not happy with the identified features of the feedback provided in an online assessment.

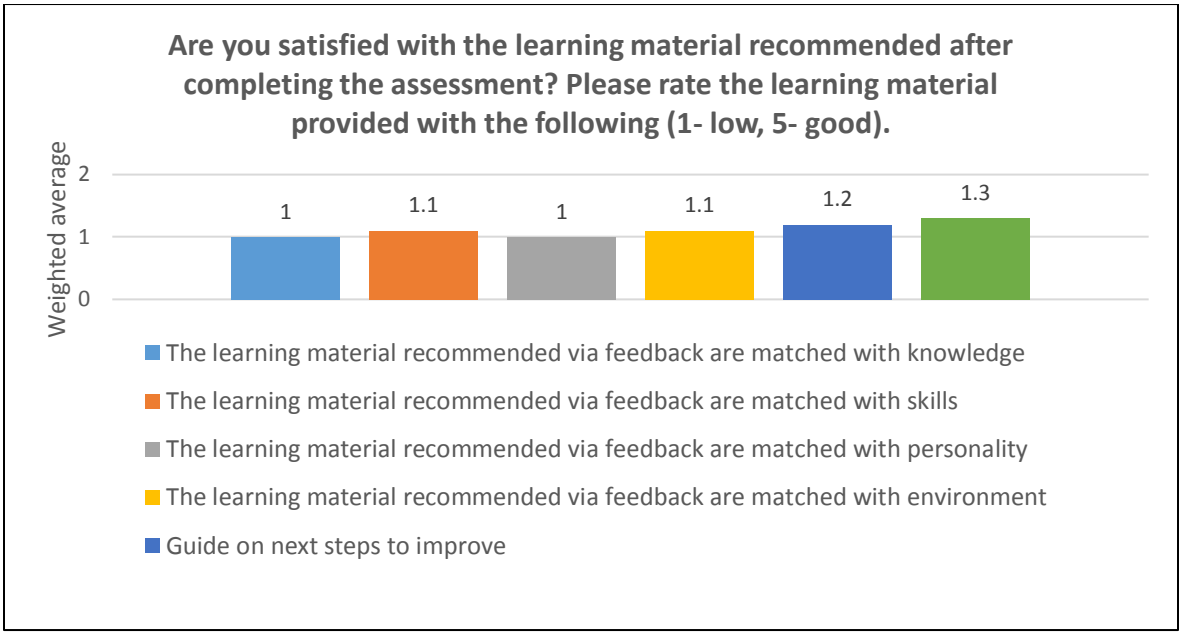

Figure 4.9: Weighted average for satisfactory level of learning material recommended (Self composed)

When the weighted average of the responses is considered, it can be clearly seen that the users are unhappy with the learning material recommended via feedback.

4.2.5. Interviews

Interviews are one of the best ways for a rich collection of information from stakeholders. Interviews are conducted with both domain expertise and instructors. Separate list of questions was made to ask from these 2 groups and 5 stakeholders from each category were considered and it took more than 2 weeks to get requirements from them. The questions asked during the Interview process are mentioned in the Appendix F and Appendix G.

4.2.5.1. Limitations of the Interviews

Limitation Id 1	**Preservation of self-interests**
Certain instructors and e-learning domain experts were not cooperative in answering certain questions as they felt that those questions were trying to meld with their business operations. Therefore, the gathered responses may not represent the absolute view e-learning systems.	

Limitation Id 2	Lack of knowledge
Certain online news editors were not technically competent enough to understand the functionalities of recommendation system. Therefore, they were unable to provide a clear feedback on a number of technical questions.	

Figure 4.10: Limitations of the interviews (Self composed)

4.2.5.2. Requirement Elicitation of the Interview

The results of the conducted interviews are analyzed below. Interviews were conducted with 2 stakeholder groups and the first group was the e-learning instructors while the other group was the e-learning domain experts.

4.2.5.2.1. Interviewing E-Learning Instructors/Tutors

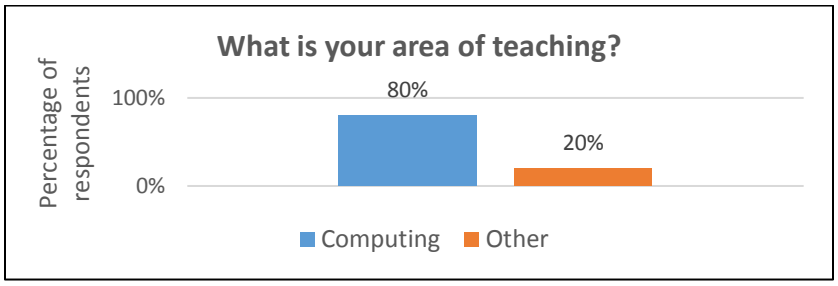

Figure 4.11: Area of teaching representation (Self composed)

Among the interviewed instructors most of them teach computing and when the question 'Do you assess students using e-learning systems?' was asked from them all of them replied with a 'yes'.

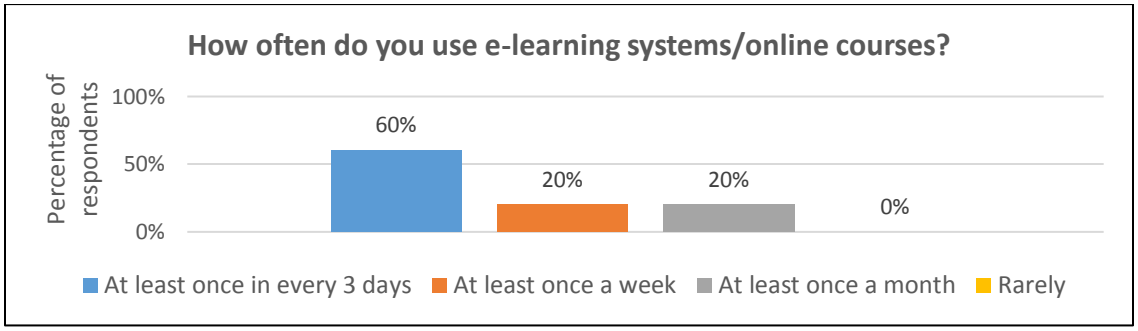

Figure 4.12: E-learning systems access frequency (Self composed)

The above figure 4.12 shows that nearly 60% of e-learning instructors use e-learning systems at least every 3 days.

The one of the main questions asked from them was "How do you provide feedback to the students when you are using an online assessment system?" The received answers can be summarized as below:

- Provide feedback manually by asking students to come and meet.

- Email the manual feedback.
- Provide the correct and wrong answers at the end of the quiz with a small explanation.

The received answers for the question “What do you want to include in a feedback provided to a student?” are:

- Explanation for what went wrong.
- Learning material recommendations matched with knowledge.
- Guide on next steps to improve.

4.2.5.2.2. Interviewing E-Learning Domain Experts

From the interviews conducted with e-learning domain experts’ majority of them suggested that the recommending personalized LM is the new trend, but still there are a lot more to improve in providing learning material recommendations. As per them:

- Most of the recommended LM per a course is static.
- The course content has considered while recommending LM, but not the students’ knowledge.
- Some have considered user previous readings, i.e. browser history while recommending LM.

Most of them accepted that Moodle is the best LMS since it can be adapted easily in order to match with individual requirements.

4.2.6. Literature Review

Literature Reviewing is the best requirement elicitation technique to have a deep understanding about the topic and to be aware about many different views of domain experts (S. G. Gunda, 2008). Proper literature review means reviewing all existing documentation that holds data belonging to proposed solution. But it has been found that literature review will not stand alone in requirement identification. Although it takes a lot of time to read and evaluate what solutions exist, there is no other way to find about most of the existing similar products.

Conducting a literature survey is not that easy as requirement gathering from stakeholders. Started with accessing IEEE library for similar projects and then moved forward to accessing other libraries. It took nearly 2 months to complete the literature survey.

4.2.7. Findings Derived from Requirement Elicitation

Table 4.13 provides a summarized set of findings gathered through all requirement elicitation methods discussed.

Id	Finding	Literature review	Questionnaire	Formal interviews	Observations	Self-evaluations
1	Should use a hybrid recommendation algorithm for the recommending learning material.	✓		✓	✓	✓
2	Should be developed specifically to provide a higher accuracy rate and maintain a higher adaptability.	✓		✓		
3	Should provide an accuracy rate of 70%				✓	✓
4	LM should be recommended based on the content of the material matched with the user preferences and knowledge.	✓	✓			
5	Most users prefer a web application for online courses.		✓			✓
6	User reading preferences identification will have more effect on the accuracy of the system.	✓		✓	✓	✓
7	Learners prefer to have the option of saving the feedback for future readings.		✓		✓	
8	Users' reading history should be considered when recommending LM.		✓	✓		✓
9	User knowledge should be broken down into many levels as possible in order to increase the accuracy.		✓		✓	✓
10	Feedback should be timely and constructive.	✓			✓	

Table 4.11:Summary of findings (Self composed)

4.4. Scope Refinement

Elaborated feedback with recommendations of LM will be generated to online assessments based on user knowledge level and characteristics such as:

- Knowledge – Knowledge is analyzed based on the topic area which a question belonging to. History of other quizzes, knowledge history of previous quiz attempts, knowledge per each topic, knowledge based on difficulty level, attempt progress, average grading, keywords belonging to the knowledge etc. are considered to find user knowledge.
- Personal data – name, gender, age, etc.

- Interaction parameters – time spent referring LM of particular topic, try data such as the number of attempts to pass the assignment, the number of times needed to give the correct answer for the certain question.

The system will not consider the time taken to complete an assessment as an interaction parameter since there is no proper research held to identify the relationship between the exam end time and user knowledge, and will not include adaptive feedback, but will contain adapted feedback and the project will end by the end of April 2015.

4.2.8. Use Case Diagram

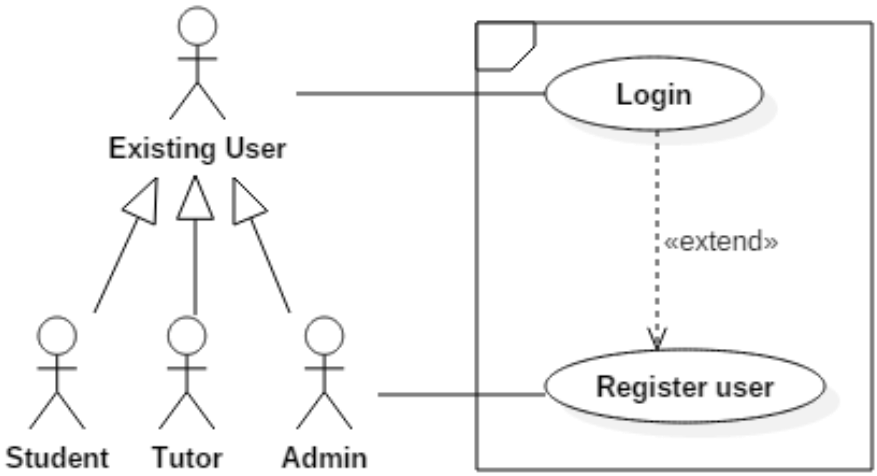

Figure 4.13: Use case diagram for login (Self composed)

The above diagram 4.13 displays the 3 types of actors that could interact with the Elaborated Feedback Generator and their login process to the system. The admin registers the other users to the system by providing a unique user name, a temporary password and the user type i.e. student or tutor. After a successful registration, a new student/tutor can login to the system. The below diagram 4.14 provides the use cases for the existing users.

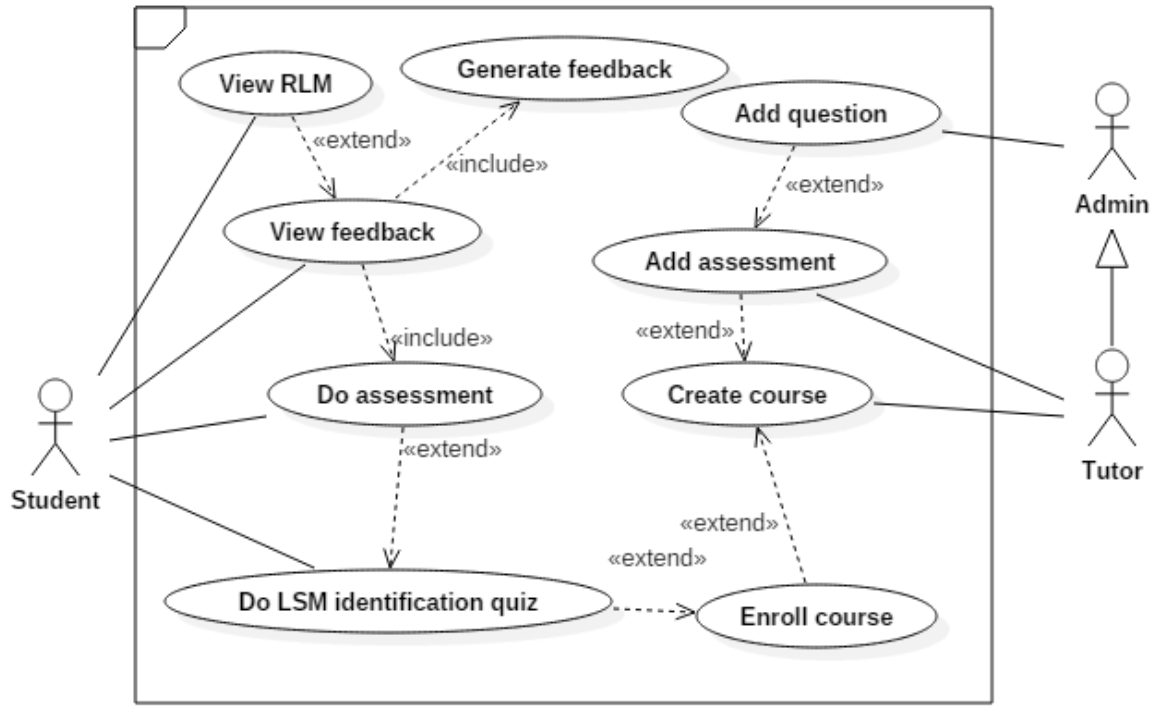

Figure 4.14: Use case diagram for Elaborated Feedback Generator (Self composed)

4.2.9. Use Case Description

Use case number:	UC1	
Use case name:	Generate feedback	
Priority:	High	
Actor:	System	
Summary:	This use case is to show the process where a feedback is generated to an assessment.	
Preconditions:	The user should be logged in to the system. The user should complete the LSM identification quiz. The user should complete at least 1 knowledge checking quiz.	
Extended use cases:	None	
Included use cases:	View feedback	
Triggering event:	The user submits quiz answers.	
Main flow of events:	**Actor**	**System**
	1. Submits quiz answers.	2. Get quiz data from the database

		3. Calculate different types of user knowledge based on the answers provided. 4. Calculate interaction data based on the time taken to do the quiz. 5. Save data in a .csv file 6. Read data from .csv file 7. Hybrid recommendation of LM based on user data 8. Generate feedback with recommendations
Alternative flow:	None	
Exceptional flow:	1. During the execution of the use case Internet connection interrupts or fails. • Use case ends in failure. 2. In step 5, fail to save the data into the .csv file. • An error message is thrown, and the use case ends in failure. 3. In step 6, fail to read data from the .csv file. • An error message is thrown, and the use case ends in failure. 4. In step 7, failed to load LM • An error message is thrown, and the use case ends in failure.	
Post conditions	Feedback is saved in the database.	

Table 4.12: Use case description for generate feedback (Self composed)

Use case number:	UC2
Use case name:	View feedback
Priority:	High
Actor:	Student
Summary:	The user views the feedback after completing the questionnaire to find out where he has gone wrong.
Preconditions:	The user should be logged in to the system. The user successfully completes the questionnaire.
Extended use cases:	View RLM
Included use cases:	Do assessment
Triggering event:	The user selects to view feedback

Main flow of events:	**Actor**	**System**
	1. Select view feedback 4. View Feedback	2. Generate feedback (UC 1) 3. Display feedback
Alternative flow 1:	 5. View Feedback	2. Feedback is already generated 3. Load saved feedback 4. Display feedback
Exceptional flow:	1. During the execution of the use case Internet connection interrupts or fails. • Use case ends in failure. 2. In step 3, failed in loading saved feedback • An error message is thrown, and the use case ends in failure.	
Post conditions	The user is presented with the feedback for an assessment.	

Table 4.13: Use case description for view feedback (Self composed)

More use case descriptions are available in Appendix H.

4.2.10. Domain Model

Below table 4.16 provides an overview of the classes contained in the domain model.

Class	**Description**
User	A user is modelled through this class.
Knowledge	A knowledge of a user belongs to a particular topic is modelled through this.
QuizSlot	A quiz slot of the questions belonging to each quiz is modeled through this.
QuestionAttempt	An attempt of a question is modeled through this class.
Question	A question is modeled through this class.
Quiz	A quiz is modeled through this class.
QuizGrade	A grade of a quiz is modeled through this class.
QuizAttempt	An attempt of a quiz is modeled through this class.
KnowledgeCalculator	This class calculates user knowledge based on the topic, interaction data and find learning preferences of users. Each knowledge type is given a value in the range of 0-1 while interaction level may have a value from -1 to 1. Learning preferences will be found, according to the FSLSM.

Recommender	This class generates the final recommendations for each topic of the user.
LearningMaterial	A learning material is modeled through this class.
ContentBasedFilter	Content based recommendation of learning material is carried out by this class.
CollaborativeFilter	Collaborative based recommendation of learning material is carried out by this class.
Feedback	Generates personalized feedback for users with recommendations.

Table 4.14: Overview of the classes contained in the domain model (Self composed)

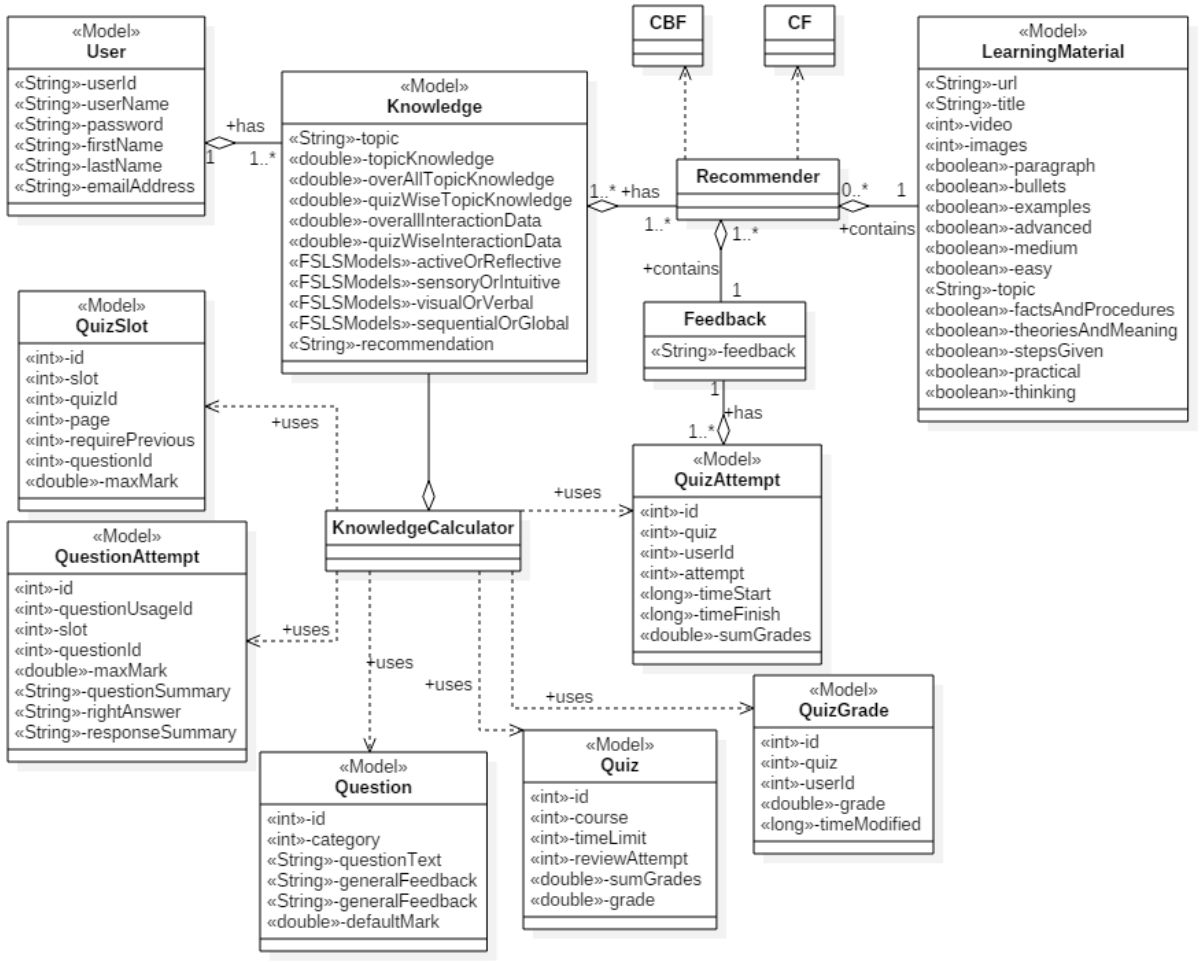

Figure 4.15: Domain model (Self composed)

4.2.11. Functional Requirements

4.2.11.1. Requirement Prioritization

Due to time and resource restrictions it might be difficult to implement every identified requirement in the requirement elicitation process. So the identified requirements are prioritized in order to identify the most

important and least important requirements. The following table 4.17 shows the priority levels and the descriptions of it.

Priority level	Description
Critical (C)	Functional requirements of the 'Critical' category represent the core functionality of the system, and it is mandatory to be implemented
Important (I)	The functional requirements of this category are not essential, but they are considered to be necessary.
Low (L)	The requirements which are intended to implement in further developments or out of the scope for the project.

Table 4.15: Priority level (Self composed)

The following table 4.18 shows the identified functional requirements along with the priority levels.

Functional Requirement		Mapped Use Case	Priority
FR1.	**Registered users should be able to login to the system** - Any registered user should be able to login to the system using his/her username and password and the system should authenticate the user.	UC5	C
FR2.	**A student should be able to do assessments of the enrolled courses** - User should be able to do an assessment after login to the system. It is required that a user should be logged in before taking an assessment because the feedback provided after the assessment is personalized and user history will be considered when generating the feedback and the student should have completed the learning style model identification quiz to get recommended LM.	UC4	C
FR3.	**Student should be able to view feedback** - User should be able to view the feedback created at the end of the questionnaire, which is personalized to him based on personalizing criteria.	UC2	C
FR4.	**Student should be able view recommended learning material** - System should recommend learning material to the user based on the knowledge in a way that effect the user positively. Those LM should be able to view by the user.	UC3	C

FR5.	**System should generate feedback** - System should generate feedback to the assessments with learning material recommendations submitted by the student.	UC1	C
FR6.	**User should be able to do quiz** – The user should be able to do quizzes belonging to a enrolled course and the quiz with Felder Silverman index.	UC6	I
FR7.	**Admin should be able to enroll the students to courses** – The system should allow the admin to enroll particular students to a course.	UC7	I
FR8.	**The tutor should be able to create a course** – The system should allow a tutor to create a course and the quizzes can be added to these courses.	UC9	I
FR9.	**The tutor should be able to create a quiz** – A tutor/teacher should be able to add assessments to the system after login.	UC10	I
FR10.	**A tutor/teacher should be able to add questions -** A tutor/teacher should be able to add questions and marking scheme for the assessments.	UC11	I
FR11.	**Admin should be able to sign up users to the system** - Admin should be able to create accounts for the students/tutors and add them to the system.	UC8	L

Table 4.16: Functional requirements (Self composed)

4.2.12. Nonfunctional Requirements

NF1. **Usability** - Usability is the ease of learning to operate, prepare inputs for, and interpret outputs of a system. The Elaborated Feedback Generator should guarantee a high level of usability for the users. Usability plays an important role in proving the assessment and feedback because the proposed solution is going to provide a solution to the overloaded informaton problem in e-learning. So if the usability level is low in the solution the aim of providing the solution will not be achieved.

NF2. **Performance** - Performance is the speed of an operation. Feedback generation should not take a longer time, although many factors are considered to generate feedback. Else the user's interest in viewing the feedback will reduce.

NF3. **Accuracy** - Accuracy of personalized feedback generation with recommendations of learning material should be at a desirable level. For a newly registered user the system expects to provide accuracy above 40% and for an already registered user who has substantially interacted with the system it expects to provide accuracy above 70%.

NF4. **Extendibility** - Proposed solution should adhere to extensibility where the system design principle and implementation creates future growth. Extendibility will be considered from the early stages of the implementation.

NF5. **Maintainability** - From the beginning of the development phase this will be considered and this research ensures the development life cycle will adhere to standards and best practices considering the end result to be worked as a dynamic component.

4.5. Chapter Summary

This chapter mainly focused on gathering accurate requirements expected from the proposed Elaborated Feedback Generator. Stakeholder analysis was done in the beginning of the chapter and the stakeholder roles were identified via an onion diagram while a context diagram paved way to better understand the data flows between the proposed Elaborated Feedback Generator and its stakeholders. Next compared the different elicitation techniques and identified the best techniques to gather requirements from different user groups. Questionnaire, interviews and literature surveying were the main elicitation techniques used apart from the self-observations. A questionnaire was used targeting e-learning students, while interviews and a brainstorming sessions were conducted with instructors and domain experts. Literature survey was used to find about similar projects. Later all the collected results were analyzed and documented to polish user requirements, identify the project scope and formulate a solution to the problem. In the end a scope refinement was done with explaining the functionalities of the system using use case diagram, use case descriptions, domain model, the set of functional and non-functional requirements. The next chapter will be the System Architecture and Design, which will be focusing on the detailed system design of the prototype based on the requirements identified from this chapter.

Elaborated Feedback Generator

Chapter 5: System Architecture & Design

- Chapter Overview
- Architecture Goals and Constraints
- High Level Design
- System Design
- ER Diagram
- Sequence Diagrams
- Class Diagram
- Chapter Summary

5.1. Chapter Overview

The previous chapter identified the requirements of the elaborated feedback generating system. This chapter will discuss the design and the architecture of the elaborated feedback generating system. Primarily, it will identify the high level design of the proposed solution. The architecture goals, constraints, risks, development approach have considered too. The chapter will also deliver a critical reasoning why the particular technology/ technique/ library was used so that the conclusions can be made as to how the development can be proceed.

5.2. Architecture Goals and Constraints

The architecture goals are listed in the below table 5.1.

Content	Description	Solution
Accuracy	Accuracy of all the modules is essential to generate feedback successfully with LM recommendations. The system should have an accuracy level of more than 70% when recommending learning material.	Accurate During the design phase careful consideration was given to achieve the highest accuracy rate by using accurate algorithms to calculate knowledge and recommend LM.
Scalability	The Elaborated Feedback Generator should be scalable when the thousands of learning material data and thousands of user quiz details are stored.	Select an appropriate data storing structure which matches with other architectural concerns too.
Extensibility	The proposed solution should be able to extend to support new features in the future.	A properly structured design.

Table 5.1: Architecture goals and constraints (Self composed)

5.3. High Level Design

The high-level design delivers an accurate picture of the final goal and the process which needs to get in there, by allowing filling the details later on the exact steps and configurations which are needed for everything to fit together.

5.3.1. Rich Picture of the Elaborated Feedback Generator

The below figure illustrates the rich picture diagram of the elaborated feedback generating system.

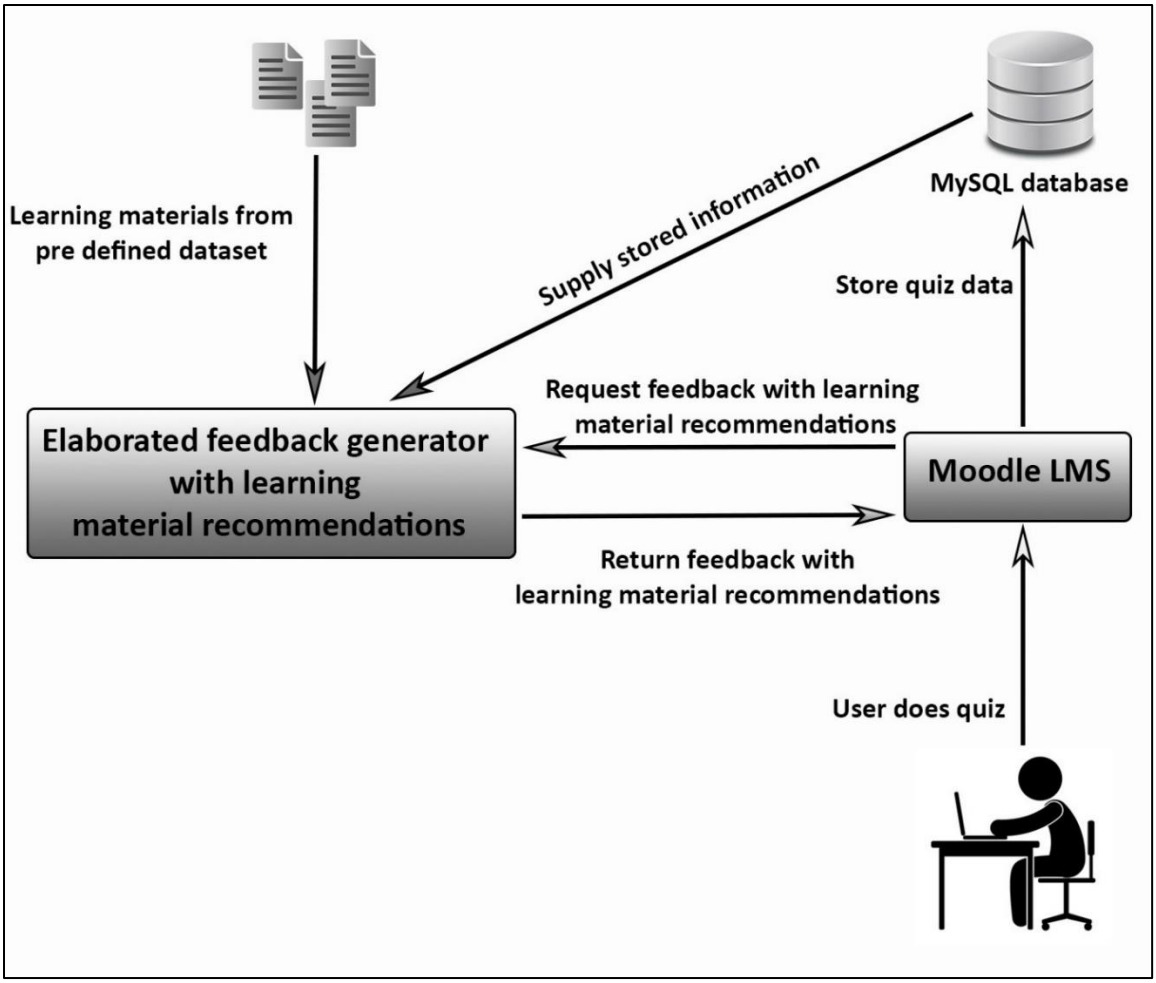

Figure 5.1: Rich picture diagram of Elaborated Feedback Generator (Self composed)

5.3.2. High Level Architecture

Three - Tier architecture is an industry-accepted software architecture model which supports modelling of enterprise-level client/server applications. The main advantage of the three-tier architecture is the independency of the three tiers from allowing any of the three tiers to be upgraded or replaced independently. This is capable of resolving issues like scalability, security and fault tolerance problems. The high level architecture of the proposed solution was modelled using the three tier architecture as displayed in the below figure 5.2.

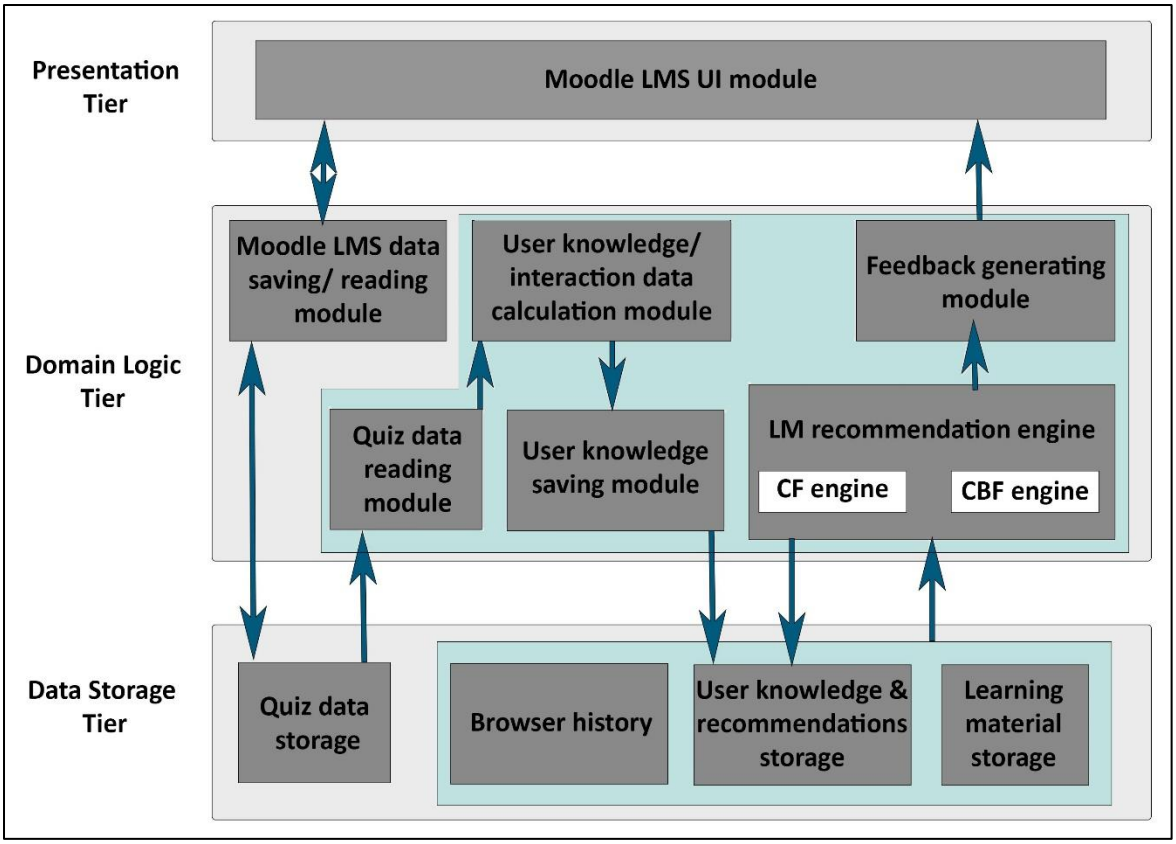

Figure 5.2: High level architecture of Elaborated Feedback Generator (Self composed)

5.3.2.1. Presentation Tier

According to the above diagram, the presentation tire consists of Moodle LMS UI module and this will be exposing the system to the external world. This module is used to display the assessments to the user and to display the feedback per assignment with recommendations of LM. There are 2 main types of assessments to answer by the users. The first type is the quiz developed using the FSLSM index. The particular quiz is mandatory to be done as the initial step by any user who logs in to the system. The other type of the quiz is the quizzes developed subject wise, which will assess the users based on their knowledge and users will be getting feedback based on this type of quizzes.

5.3.2.2. Domain Logic Tier

The domain logic tier contains few modules consisting of the business logic of the proposed solution. They are:

- **Moodle LMS data saving/ reading module** – This module writes user question answers related data to the database and reads data from the database to be loaded and displayed to the user.
- **Quiz data reading module** – The purpose of this module is to read the data from the database and to provide those data to the User knowledge/ interaction data calculation module.

- **User knowledge/ interaction data calculation module** – This module calculates the user knowledge based on the question answers, interaction level of the users based on interaction data and identifies user learning style models.
- **User knowledge saving module** – This module saves calculated user knowledge under different areas in the format of csv.
- **LM recommendation engine** – The recommendation of LM will be performed by this module and this module contains 2 sub modules as CF engine and CBF engine. CF engine would provide recommendations based on the content alignment of the user profile and article descriptors while CBF engine will provide recommendations based on the user clusters based and web page ratings.
- **Feedback generating module** – This module generates the feedback combining the recommendations found through the recommendation engine.

5.3.2.3. Data Storage Tier

Data storage tier contains with 4 data storage units which stores the information used in the process of recommending learning material and generating elaborated feedback.

- **Quiz data storage** – This is the default database of Moodle LMS using MySQL. This storage stores the data needed to create an assignment via Moodle with the students' marks when the assignment is done.
- **Browser history** – This is the browser history file on your computer, the browser history provides details of the particular topic related data access time and the user interests.
- **User knowledge and recommendation storage** – This storage contains the previous recommendations for users with their knowledge levels break down into many sections and reading preference based on the topic in .csv file format.
- **Learning material storage** – This storage consists of 2 main storages, they are the .csv files containing:
    - Different LM based on the topic with their content type and learner preference type.
    - LM with their keyword frequencies/ ratings.

5.3.3. Algorithm Design to Identify User Knowledge, Interaction Data and Learning Style Model

Algorithms to identify user knowledge and interaction data were designed in the same way where they get a value within the range of 0 – 1 based on answers they provided to questions, number of attempts to provide a correct answer, the progress of knowledge and time spend reading learning materials. These calculations are made by identifying the topic areas of questions in an assessment. The learning style models of the users are found using

the FSLSM index where each user is identified with 4 Learning Styles. The algorithms are described in more details in the section 6.4.1.

5.3.4. Recommender Algorithm Design

According to Burke, R. (2007) there are 7 basic design approaches as described in the section 2.7.1.4 which can be considered while designing a hybrid recommendation system and it was decided to adopt the Meta-level hybrid approach where one recommendation approach users the trained data from other approach as the input. When adopting this approach to the proposed system, the CF approach will use the model trained by the CBF approach as the input and recommend LM for users with the similar type of knowledge, interaction parameters and reading preferences.

5.3.5. Selection of Design Methodology

Design methodology is a set of procedures that follows to complete a software development process from the beginning. The nature of the design methodology is dependent on several factors such as software development environment, type of the software being developed, the requirements of the users, and the time schedule. Although some design methodologies are available, the widely used two methodologies by the industry are:

- Structured Systems Analysis and Design Method
- Object-Oriented Analysis and Design Method

5.3.5.1. Application of Object-Oriented Analysis and Design Method

OOADM is a standard technical approach for analyzing and designing an application or a system by applying the object-oriented pattern and visual modeling throughout the development life cycles to improve the product quality and for the better stakeholder communication. This is widely used in the industry as one of the main development methodology due its capability in modelling complex and larger software. OOADM is able to break complex software systems down into various objects, combining the data and the functions that operate with the data into a single unit.

Since the implementation of the domain logic tier is based on Java and the Presentation tier is based on Moodle the OOADM approach and the UML was selected as the technique for representing the model.

5.4. ER Diagram

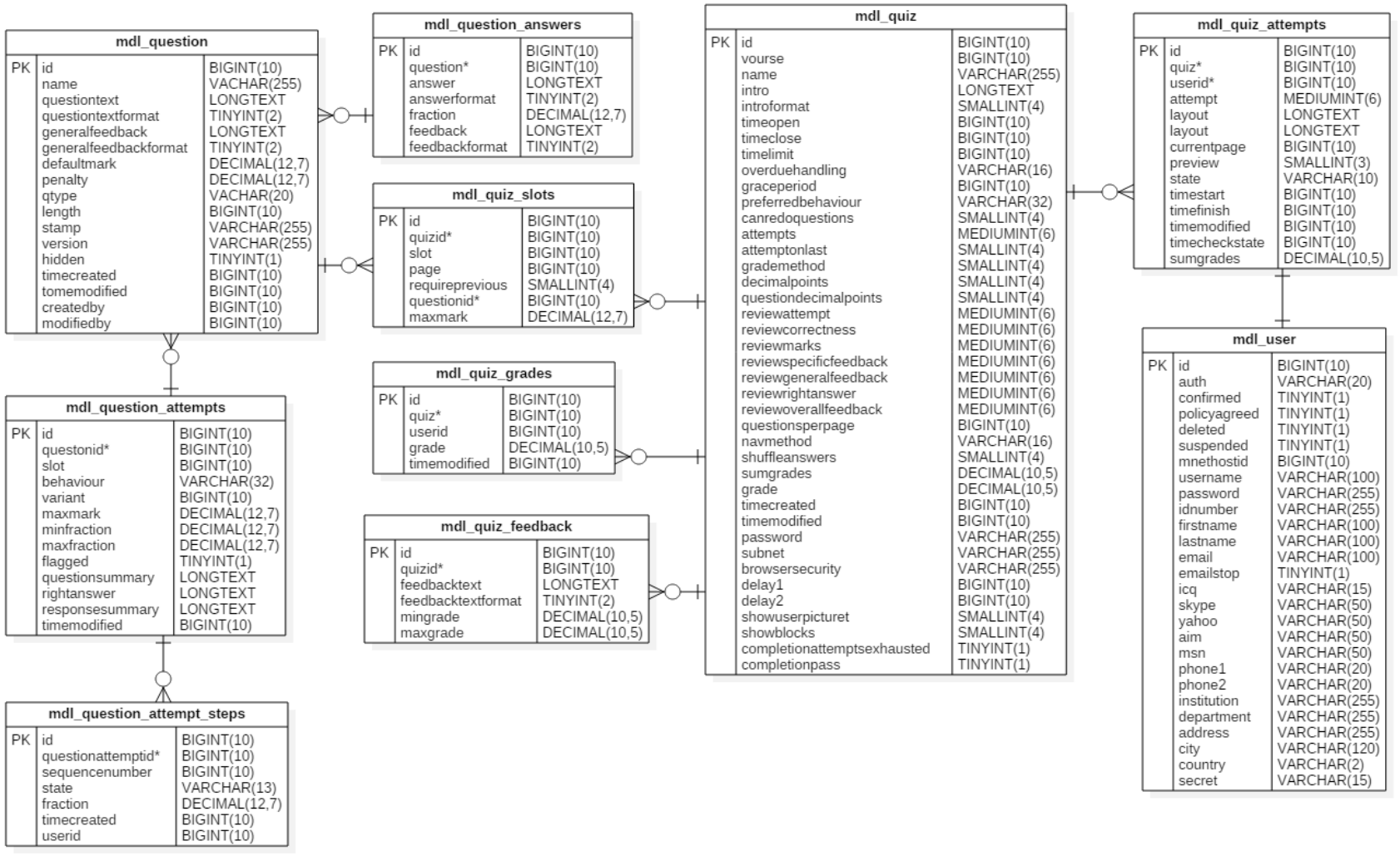

Table 5.2: ERD (Self composed)

The ERD for browser history database can be found in Appendix I.

5.5. Sequence Diagrams

5.5.1. Sequence Diagram for Generate Feedback

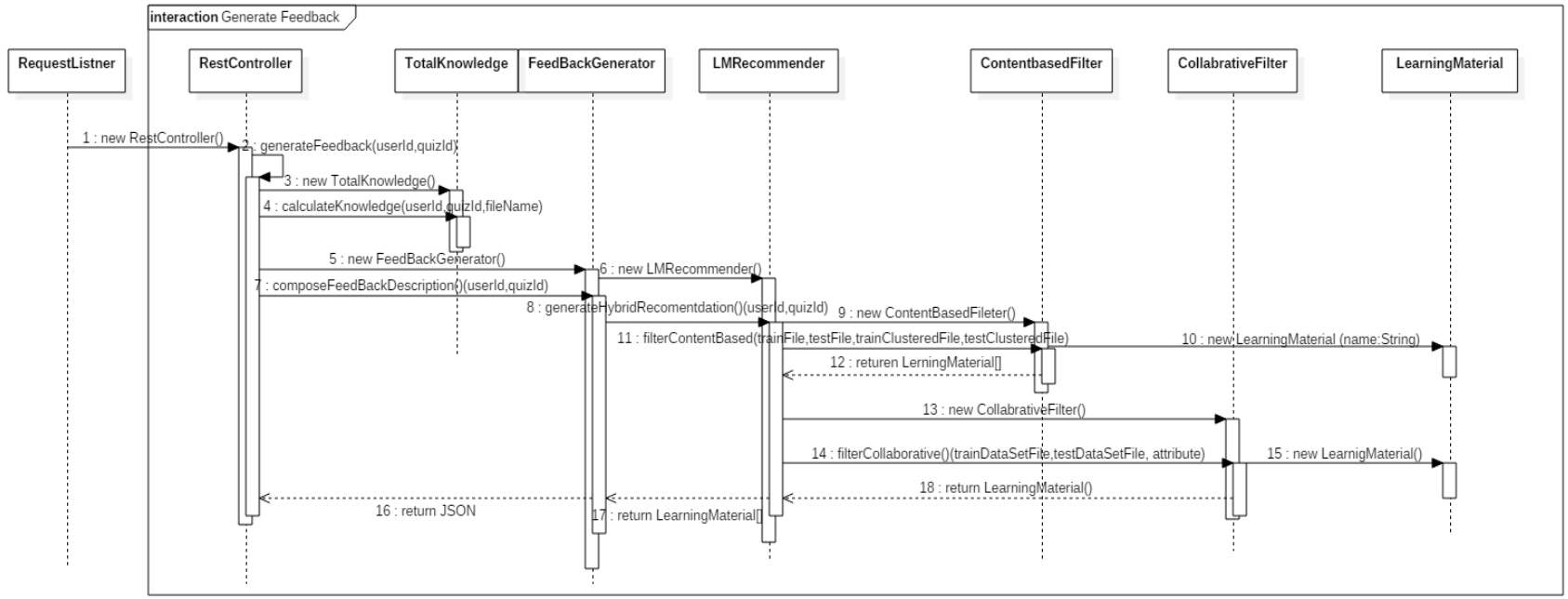

Figure 5.3: Sequence diagram for generate feedback (Self composed)

5.6. Package Diagram

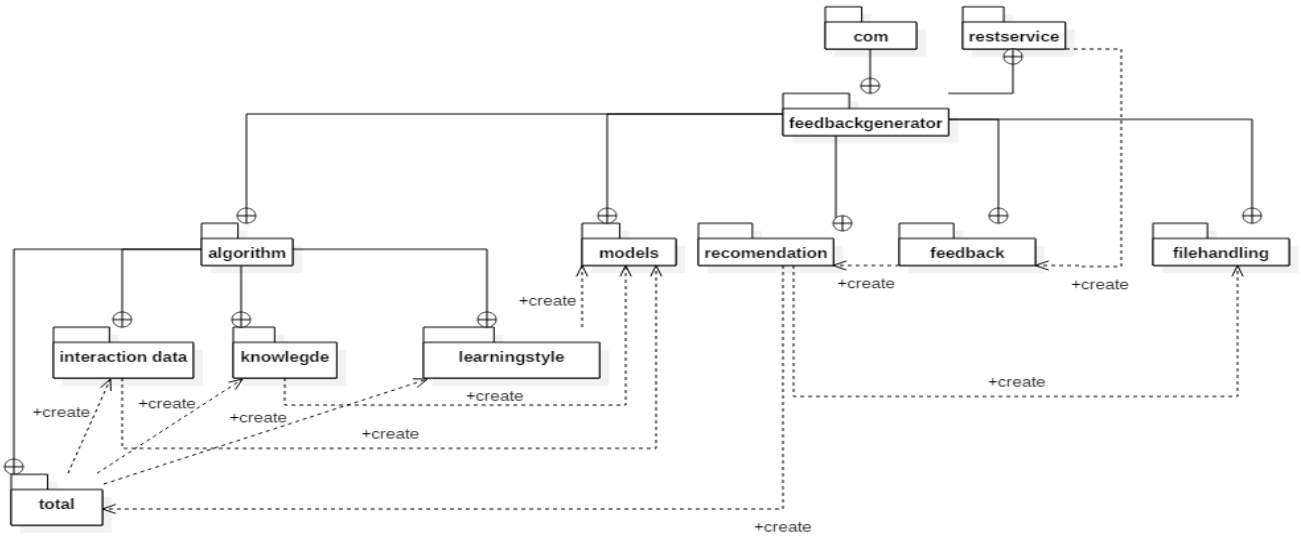

Figure 5.4: Package diagram (Self composed)

5.7. Design Optimization

Object Pool Design Pattern

In order to optimize the design and the architecture a design pattern was used. The object pooling design pattern was selected as the design pattern due its significant performance improvement. It is most effective in situations where the cost of initializing a class instance is high, the rate of instantiation of a class is high, and the number of instantiations in use at any one time is low. The Object Pooling Design Pattern was applied to creating the connection pool.

5.8. Chapter Summary

This chapter discussed the architecture and the design of the elaborated feedback generating system. The chapter started with identifying the architectural goals as accuracy, scalability and adaptability. Then the high-level design of the solution which was modelled and discussed in terms of modules which it contains. The Moodle LMS data saving/ reading module, Quiz data reading module, User knowledge/ interaction data calculation module, User knowledge saving module, LM recommendation engine and the Feedback generating module were the main modules identified. Then the chapter discusses about the hybrid recommendation algorithm and then moved on to describe low level design diagrams such as class diagram and sequence diagrams. Finally, the ER diagram of the proposed system was displayed. The next chapter will focus on the prototype implementation of the Elaborated Feedback Generator.

Elaborated Feedback Generator

Chapter 6: Implementation

- Chapter Overview
- Technology Selections
- Implementation of REST Service
- Core functionalities
- Chapter Summary

6.1. Chapter overview

The previous chapter discusses about the design of the proposed solution and this chapter will discuss about the implementation process of the Elaborated Feedback Generator with different frameworks, environments and APIs. The chapter includes a discussion on the technology selection for the implementation of the prototype with a justification for choosing them, detailed account of the implementation process, problems encountered while implementing the prototype and the solutions found to overcome those problems using appropriate code snippets and screenshots.

6.2. Technology selections

6.2.1. Critical Evaluation of Online Assessment Technologies

When compared to other LMS Moodle can be easily extended with custom features by writing a PHP plugin. It is also easy to use, more scalable and affordable than other proprietary LMS solutions. Moodle is superior to any other LMS in terms of collaboration and course development. So that the Moodle is used when implementing the solution. More details on other available online assessment technologies are described on appendix K section 1.

6.2.2. Critical Evaluation of Programming Language to Write the Main Component

The major research component in the Elaborated Feedback Generator is to recommend LM with the feedback make use of machine learning. This was kept in mind when selecting the programming language to write the recommendation module.

The available programming languages are described in the Appendix K, section 2. Due to the critical evaluation conducted, it can be proved that the Java is the best language to carry out the implementation.

6.2.3. Critical Evaluation of Machine Learning Libraries

For Java there are many machine learning libraries that are widely used in the industry. The machine learning libraries are evaluated in the section 3 of appendix K.

When considering the advantages and disadvantages of the widely used algorithms in the industry and how those effects on the proposed solution, it was decided to use Weka as the machine learning library. Due to the limited time given for the implementation, the time-saving technology, Weka was used since it has a GUI interface which makes the beginners task easier. The features such as containing large no of algorithms, accuracy and user friendliness for beginners made the selection easy. The only disadvantage is that there is a limited number of datasets that which can handle. Although Mahout supports a lot of datasets, the mahout is not feasible as Weka and as it does not have a GUI interface it takes more time to implement due to the less user friendliness. But when

considered the datasets that the proposed solution is using, a conclusion can be made that the features provided by Weka are more than enough for the implementation of the proposed solution.

6.2.4. Feedback Generating Service Exposure Approach

There are 2 main approaches which can be followed to expose the feedback generating service. They are SOAP and REST.

SOAP	REST
• Permits only XML data type. • Supports WS-Security which adds few enterprise security levels. • Provides a standard implementation of data integrity and data privacy.	• Permits many data formats like JSON. • REST uses standard HTTP, so that it is much simpler. • REST allows better support for browser clients due to its support for JSON. • REST has better performance and scalability

Table 6.1: SOAP vs REST (Self composed)

It was decided to use REST since it is used by any type of a client, light weight and there are advanced security mechanisms adopted with REST.

6.2.5. Selection of Data Storage

Moodle users MySQL as its default data storage, due to this it is easier to use MySQL as the data storage rather than going for another database type in order to store student assessment related data.

Weka supports MYSQL databases, .csv files or .arff files as data storages. So in order to store the data needed for the recommendation module to generate recommendations .csv files were used. This is because of easy accessibility of .csv files from Java code and easy computation of data with Weka.

6.2.6. Selection of a JSON Object Serializer

The REST web services communicate using serialized JSON objects. Due to this there should be a serializer to convert a feedback object into JSON format. For this it was decided to use the open source library Jackson.

6.2.7. Selection of Key Words Identification API

The AlchemyLanguage API was selected as the key word extraction API, since it extracts both key words and concepts from any given URL. Since the concepts are extracted the accuracy level may increase by using the AlchemyLanguage API.

6.2.8. Selection of an IDE and a Deployment Environment

It was decided to use IntelliJ as the IDE and Apache Maven as the deployment environment due to the previous exposure. Apache Maven was selected due to its capability in resolving the project dependencies intelligently without struggling.

6.3. Implementation of REST Service

The Elaborated Feedback Generator which forms combining the quiz data reading module, user knowledge/ interaction data calculation module, user knowledge saving module, LM recommendation module and feedback generating module was decided to implement as a web service which will be developed using java. Below figure 6.1 describes how the web service was created.

```
@POST
@Path("/generateFeedback")
@Consumes(MediaType.APPLICATION_JSON)
public Response generateFeedback(InputData input) {
    int userId = input.getUserId();
    int quizId = input.getUserId();

    FeedbackGenerator feedbackGenerator = new FeedbackGenerator();
    Feedback feedback = feedbackGenerator.generateFeedback(userId, quizId);

    ObjectMapper objectMapper = new ObjectMapper();

    try {
        Object json = objectMapper.readValue(objectMapper.writeValueAsString(feedback),
                Object.class);
        return Response.status(200).entity(json).build();
    } catch (IOException e) {
        return Response.status(500).entity("Feedback is empty").build();
    }
}
```

Figure 6.1: Feedback generating REST service

As highlighted in the above figure there is a function to listen to the REST call via the client. The user id and the quiz id are sent as a JSON object as the content of the POST request. It calls the feedback generation method and returns the feedback object converted in to a JSON as the response. The serialization of the JSON objects is handled by Jackson.

Complexity of the code: Hosting a rest service through Java is not too complex. But since it was the first time it was a challenging task.

Problems faced: None

6.4. Core functionalities

6.4.1. Implementation of User Knowledge, Interaction Data and Reading Preference Identification Module

6.4.1.1. Identify User Knowledge Level

User knowledge should be found in order to recommend personalized LM for a user and knowledge is the main factor considered while recommending LM. User knowledge is identified based on the answers provided for an assessment by a user. Users' answer history is saved for each assessment attempt and the knowledge is evaluated for a user mainly based on the attempt wise and overall performance wise. It was found that more sections that the knowledge is broken down into will produce more accurate recommendations. The user knowledge per each topic of the quiz was broken down into 18 sub sections such as:

- Topic knowledge
- Overall topic knowledge
- Quiz wise topic knowledge
- Advance topic knowledge
- Overall advance topic knowledge
- Quiz wise advance topic knowledge
- Easy topic knowledge
- Overall easy topic knowledge
- Quiz wise easy topic knowledge
- Knowledge (total knowledge)
- Overall knowledge
- Quiz wise knowledge
- Advanced knowledge
- Overall advanced knowledge
- Quiz wise advanced knowledge
- Easy knowledge
- Overall easy knowledge
- Quiz wise easy knowledge

Each knowledge was calculated in a manner where they get a value within the range of 0 – 1.

Example: Consider a user who answers a quiz and that quiz contains advanced and easy questions belong to Java method overloading. That user has 18 values for the above mentioned knowledge categories per each unique topic of the quiz.

When calculating each sub category knowledge, algorithms were wrote considering the user grading and grading progress as displayed in the below figures of 6.2 and 6.3.

```
public double findTopicOrDifficultyProgress(int userId, String topic) throws Exception {
    QuizAttempt quizAttempt = new QuizAttempt();
    ArrayList<Integer> userQuizIds = quizAttempt.getUserQuizIds(userId);

    ArrayList<Double> userQuizGrades = new ArrayList<~>();

    for (int i = 0; i < userQuizIds.size(); i++) {
        QuizSlot quizSlot = new QuizSlot();
```

```
        // get the question ids of questions belonging to a particular quiz
        ArrayList<Integer> questionIds = quizSlot.getNameWiseQuestionIdsOfAQuiz(userQuizIds.get(i), topic);

        Progress progress = new Progress();
        double quizGradingProgress = progress.findQuizProgress(questionIds, userId);

        userQuizGrades.add(quizGradingProgress);
    }

    double quizProgress = 0;

    for (int i = 0; i < userQuizGrades.size() - 1; i++) {
        if (userQuizGrades.get(i + 1) >= userQuizGrades.get(i)) {
            quizProgress += 1;
        }
    }

    double quizGradingProgress = 0;
    if (quizProgress != 0 && userQuizGrades.size() > 1) {
        quizGradingProgress = quizProgress / (userQuizGrades.size() - 1);
    }

    return quizGradingProgress;
}
```

Figure 6.2: Calculating the difficulty progress based on the topic

```
public double findTopicOrDifficultyGrade(int userId, String topic) throws Exception {
    QuizAttempt quizAttempt = new QuizAttempt();
    ArrayList<Integer> userQuizIds = quizAttempt.getUserQuizIds(userId);

    ArrayList<Double> userQuizGrades = new ArrayList<~>();

    for (int i = 0; i < userQuizIds.size(); i++) {
        QuizSlot quizSlot = new QuizSlot();
        // get the question ids of questions belonging to a particular quiz
        ArrayList<Integer> questionIds = quizSlot.getNameWiseQuestionIdsOfAQuiz(userQuizIds.get(i), topic);

        Grade grade = new Grade();
        double quizGrade = grade.findQuizGrade(questionIds, userId);

        userQuizGrades.add(quizGrade);
    }

    double quizGrade = 0;

    for (int i = 0; i < userQuizGrades.size(); i++) {
        quizGrade += userQuizGrades.get(i);
    }

    double averageQuizGrade = 0;
    if (quizGrade != 0 && userQuizGrades.size() > 0) {
        averageQuizGrade = quizGrade / userQuizGrades.size();
    }

    return averageQuizGrade;
}
```

Figure 6.3: Calculating the grade obtained for difficulty level based on the topic

Complexity of the code: Writing knowledge calculating algorithms in Java is not a very challenging task as what have to be done is writing the algorithms in order to assign a value to different knowledge categories based on the answers which the students provided for assessments. But prior to writing the algorithms there was a challenging task. That was to properly breakdown the knowledge in order to improve the accuracy of recommendations and while the algorithms, the accuracy of the algorithms should be highly concerned.

Problems faced: Difficulties were faced while identifying the proper breakdown of knowledge categories to obtain a high accuracy.

6.4.1.2. Identify User Reading Preferences

There was a quiz made using FSLSM index to identify learning style model of the users. Users were given marks based on the selections they made and their learning style was identified based on the marks. There are all together 44 questions where there are 11 questions to identify each category out of 4 main categories.

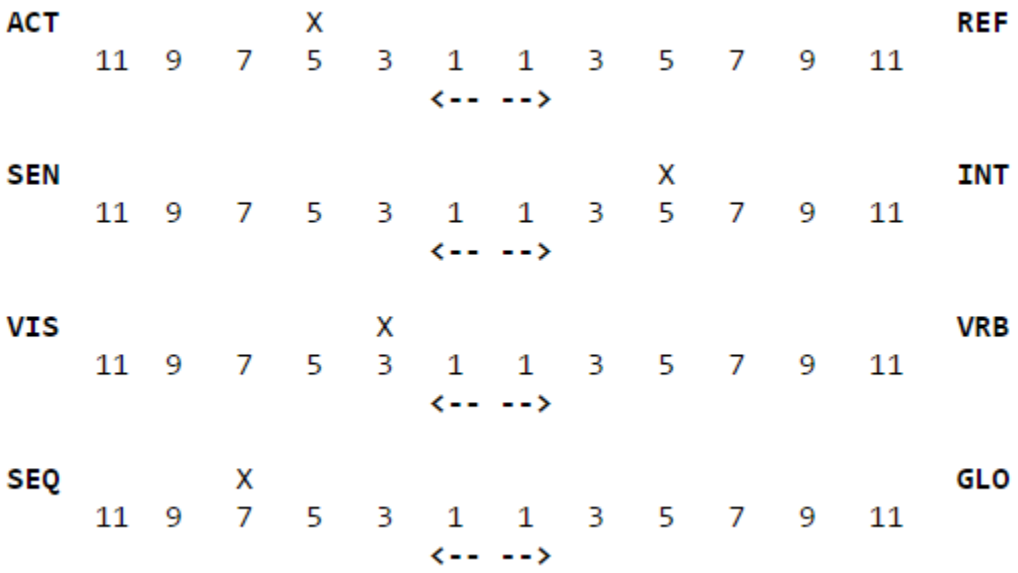

Figure 6.4: FSLSM index (Felder R. M.,2002)

- If the score is 1-3, user is fairly well balanced on the two dimensions of that scale.
- If the score is 5-7, user is a moderate preference for one dimension of the scale and will learn more easily in a teaching environment which favors that dimension.
- If the score is 9-11, user has a very strong preference for one dimension of the scale. They may have real difficulty learning in an environment which does not support that preference.

Complexity of the code: It was not challenging since each and every step is described in the FSLSM.

Problems faced: None

6.4.1.3. Identify Interaction Data

User interaction data should be considered in order to recommend LM as users differ from the interaction parameters. The time spent viewing LM belonging to a particular topic, the number of attempts to give a correct answer to a particular question was considered and generated a value with in the range of 0 – 1, attempt wise and overall quizzes wise.

```
public double calculateTimSpentViewingMaterial(String topic) throws SQLException, ClassNotFoundException {
    History history = new History();
    long topicTime = history.getTopicViewingDuration(topic);
    long totalTime = history.getTotalBrowsingDuration();

    double value = 0;
    if (topicTime > 0 && totalTime > 0) {
        value = topicTime / totalTime;
    }

    return value;
}
```

Figure 6.5: Calculating time spent viewing learning material

The above code snippet displayed in the figure 6.5 has considered the user total browsing history and found the time taken to view the materials from particular topic.

Complexity of the code: Writing interaction level calculating algorithms trough Java is not a very challenging task as what have to be done is writing the algorithms in order to assign a value to interaction parameter based on the time spent viewing LM and the number of attempts taken to provide a correct answer.

Problems faced: It was unable to find the 100% accurate relationship between the time spent for an assessment and the impact of it to the students grading. So that considering the assessment time was omitted while calculating the interaction level of a student.

6.4.2. Implementation of Learning Material Recommendation Module and the Feedback Generating Module

6.4.2.1. Recommend Learning Material

LM are recommended based on the user knowledge, personal data, and interaction data found in the previously described module. The recommendation was made through collaborative filtering approach and the content based filtering approach. The below diagram 6.6 displays how the hybrid recommendation works. The

recommendations made through content based filtering are filtered through collaborative filtering to generate the hybrid recommendation.

```
// hybrid recommendation
TotalKnowledge totalKnowledge = new TotalKnowledge();
CSVFileWriter csvFileWriter = new CSVFileWriter();

CollaborativeFilter collaborativeFilter = new CollaborativeFilter();
ContentBasedFilter contentBasedFilter = new ContentBasedFilter();

ArrayList<Knowledge> knowledgesToFindHR = totalKnowledge.calculateUserTotalKnowledge(userId, quizId, setRec);
csvFileWriter.writeCsvFile("data/trainData.csv", knowledgesToFindHR);
contentBasedFilter.filterContentBased("data/trainData.csv", "data/testData.csv",
        "data/trainContentFilteredData.csv", "data/testContentFilteredData.csv");
collaborativeFilter.filterCollaborative("data/trainContentFilteredData.csv", "data/testContentFilteredData.csv",
        attributeNo);
```

Figure 6.6: Hybrid recommendation

6.4.2.1.1. Content Based Filtering

In a content-based filtering, keywords are used to describe the LM and a user profile is built to indicate the type of item this user likes. The keyword relevance with the concept relevance per each keyword and concept for LM are obtained through the AlchemyLanguage API. For the contents of the learning material the aspect of the data type which it contains such as images, videos, paragraphs and bullets are also considered. The matched user reading preference also mapped with the LM. Considering these factors, the learning material profile is made and the system creates a content-based profile of users based on the weight of learning material features. Then the data are clustered to apply the content based filtering approach to the dataset.

```
CSVFileReader fileReader = new CSVFileReader();
Instances trainData = fileReader.readDataFile(trainDataSetFile);

SimpleKMeans model = new SimpleKMeans(); //clustering using KMeans
model.setNumClusters(8);
model.setDistanceFunction(new weka.core.ManhattanDistance()); //set distance function
model.buildClusterer(trainData);

// evaluates the cluster using the ClusterEvaluation class by using separate train and test data sets
ClusterEvaluation trainEval = new ClusterEvaluation();
trainEval.setClusterer(model);
trainEval.evaluateClusterer(trainData);

ContentBasedFilter contentBasedFilter = new ContentBasedFilter();
CSVSaver saver = new CSVSaver();
contentBasedFilter.writeArff(trainClusteredDataSetFile, trainData, trainEval);

String testDataSet = testDataSetFile; //load test data set
ConverterUtils.DataSource testSource = new ConverterUtils.DataSource(testDataSet);
Instances testData = testSource.getDataSet();
```

```
// evaluates the cluster using the ClusterEvaluation class by using separate train and test data sets
ClusterEvaluation testEval = new ClusterEvaluation();
testEval.setClusterer(model);
testEval.evaluateClusterer(testData); //this should be the test data set
contentBasedFilter.writeArff(testClusteredDataSetFile, testData, testEval);
```

Figure 6.7: Code snippet of content based filtering

6.4.2.1.2. Collaborative Filtering

Collaborative filtering is an approach of making predictions and here the model based approach is selected as the collaborative filtering approach. The data are analyzed with k-NN to do the predictions by finding similar knowledge values.

```
CSVFileReader fileReader = new CSVFileReader();

Instances trainDataSet = fileReader.readDataFile(trainDataSetFile);
trainDataSet.setClassIndex(trainDataSet.numAttributes() - attribute);

int numClasses = trainDataSet.numClasses();
for(int i = 0; i < numClasses; i++){
    String classValue = trainDataSet.classAttribute().value(i);
    System.out.println("Class Value "+i+" is " + classValue);
}

IBk nb = new IBk(); //create and build the classifier
nb.buildClassifier(trainDataSet);

Instances testDataSet = fileReader.readDataFile(testDataSetFile);
testDataSet.setClassIndex(trainDataSet.numAttributes() - attribute);

for (int i = 0; i < testDataSet.numInstances(); i++) {
    double actualClass = testDataSet.instance(i).classValue();
    String actual = testDataSet.classAttribute().value((int) actualClass);
    Instance newInst = testDataSet.instance(i);
    double predNB = nb.classifyInstance(newInst);
    String predString = testDataSet.classAttribute().value((int) predNB);
    System.out.println(actual+", "+predString);
}
```

Figure 6.8: Code snippet of collaborative filtering

Complexity of the code: The recommender engine was the highest complex part of the implementation as it was the first time machine learning and the recommendation techniques were used. There were lot to research and find while coding. For writing the machine learning algorithms Weka was used and it made the task little easier.

Problems faced: The major problem occurred was to find the highest accuracy algorithm which matches with the data set which has been created by combining user knowledge. While implementation all the algorithms were

used and tested in order to find the most appropriate in the necessary category. The selection of hybrid algorithm was also problematic and tried many approaches while developing.

6.4.2.2. Generate Feedback

Recommend material found for certain topics are combined and feedback is generated and presented to the user based on the personal data.

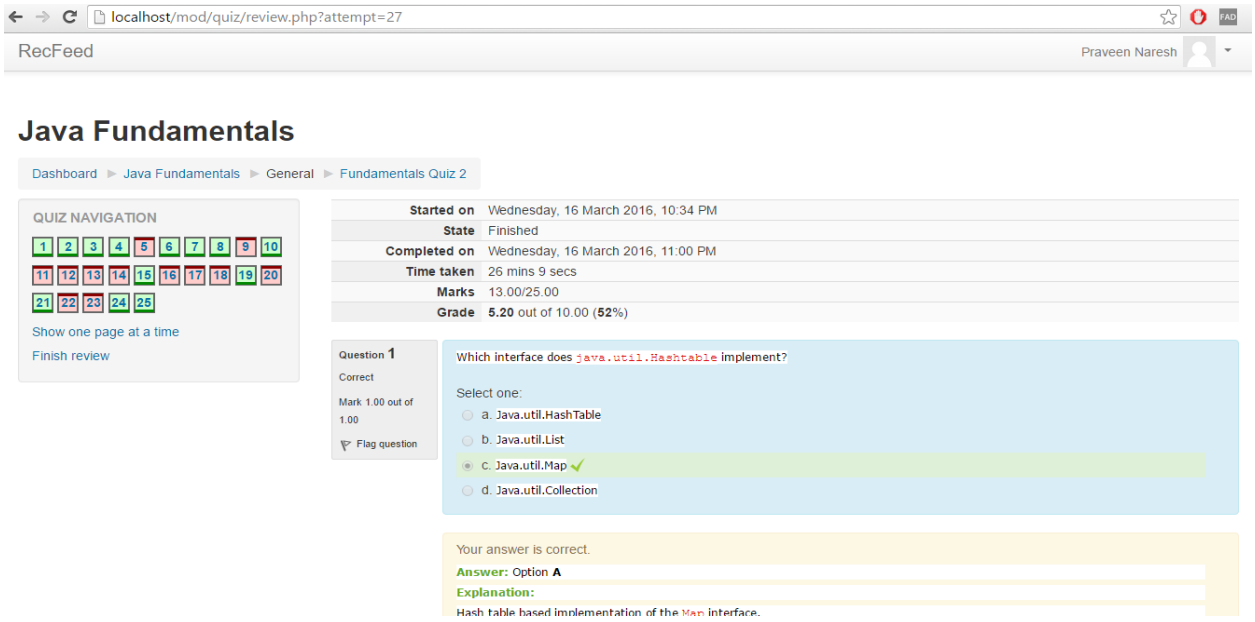

Figure 6.9: UI of the feedback display view

Complexity of the code: The code was a bit complicated as it has to connect to other modules to get recommendations and to generate feedback based on the user profile.

Problems faced: None

6.5. Chapter Summary

This chapter explained about the implementation process of the Elaborated Feedback Generating System for online assessments. The chapter started with a justification for the technology selection and it was described why Moodle, Java, Weka, REST, MYSQL, .csv storage, Jackson, AlchemyLanguage API and IntelliJ IDEA was selected. Then the chapter described how the REST service was implemented and moved on to describe the implementation of the core functionalities of the Elaborated Feedback Generator. The core functionalities described how they were implemented with the aid of code snippets and sample UIs for better understanding. With each functionality the complexity and the problems encountered also discussed. The next chapter will be on testing of the Elaborated Feedback Generator.

Elaborated Feedback Generator

Chapter 7: Testing

- Chapter Overview
- Objectives & Goals of Testing
- Testing Criteria
- Functional Requirements Testing
- Module & Integration Testing
- Non-Functional Requirements Testing
- Limitations of the Testing process
- Chapter Summary

7.1. Chapter Overview

Previous chapter discussed about the implementation of the prototype and this chapter will cover the testing phase of the development life cycle. The chapter will be on testing the functional and non-functional requirements of the Elaborated Feedback Generator in order to make sure that all the implemented requirements were completed to the expected levels. This chapter contains the testing criteria, testing methods and testing levels and finally will provide an evaluation of the testing results.

7.2. Objectives & Goals of Testing

Testing of the prototype will be done in order to validate that the completed software bundle functions according to the expectations defined by the requirements.

The main objectives of testing Elaborated Feedback Generator are:

- To verify and validate the functional requirements of the elaborated feedback generating system.
- To verify and validate the non-functional requirements of the elaborated feedback generating system.
- To recognize errors and defects of the system in order to make sure that the final product contains fewer amounts of errors and bugs.
- To further enhance the system based on the test results.

7.3. Testing Criteria

Testing the prototype in order to find whether the system has met the functional and non-functional requirements and quality expectations can be measured in 2 different ways. They are measuring the software functional quality and measuring the software structural quality.

- **Software functional quality:** Gives attention to the combination of the product development characteristics with the technical requirements of the given design based on the functional requirements.
- **Software structural quality:** Gives attention on the performance of the functional requirements of the product with the identified non-functional requirements.

7.4. Functional Requirement Testing

The spiral methodology allows the developer to conduct the testing phase in parallel with the implementation phase. So that the testing of the functional requirements was carried out with the black box testing approach, parallel to the implementation of the Elaborated Feedback Generator.

The below table 7.1 displays a summary of the results obtained after testing the functional requirements. Please refer to Appendix L for test cases and detailed description.

Functional requirement	Pass rate	Status
Admin should be able to create accounts for the students/tutors and add them to the system.	100%	Pass
Any registered user should be able to login to the system using his/her username and password and the system should authenticate the user.	100%	Pass
If the authentication fails, the system should display an error message to the user, citing the reason for the authentication failure	100%	Pass
A tutor/teacher should be able to create courses after login.	100%	Pass
A tutor/teacher should be able to add assessments to the system after login.	100%	Pass
A tutor/teacher should be able to add questions and marking scheme for the assessments.	100%	Pass
Admin should be able to enroll the students to courses	100%	Pass
A student should be able to do assessments of the enrolled courses.	100%	Pass
Student should be presented with a questionnaire to identify the learning style model.	100%	Pass
The student should have completed the learning style model identification quiz to get recommended LM.	100%	Pass
If the student has not answered the learning style model identification quiz, an error message should be displayed.	100%	Pass
User should be able to view the feedback created at the end of the questionnaire, which is personalized to him based on personalizing criteria.	100%	Pass
System should save the feedback generated.	100%	Pass
User should be able view recommended learning material.	100%	Pass
System should generate feedback with learning material recommendations.	100%	Pass

Table 7.1: Tested functional requirements (Self composed)

7.5. Module & Integration Testing

The Elaborated Feedback Generator contains a number of modules in its architecture as described in the section 5.3.2 of the design chapter. One module is coupled with another module in the form where the output of one unit is consumed by the other. Since the functionality of a unit is essential for another module to perform it was decided to conduct module and integration testing with the black box testing approach. Each and every module

was tested 10 times and the below table 7.2 delivers a summary of unit and integration testing results of the elaborated feedback generating system. The test cases are available in Appendix J.

Module	Input	Expected Output	Actual Output	Status
Moodle LMS UI Module	Answers for questions	Should display the feedback with learning material recommendations.	Feedback with learning material recommendations.	Passed
Moodle LMS data saving/ reading module	Question data, Answers, User profile	The data should be stored in MySQL database and the data from the database should read from the module.	Data are stored in the database and the data in the database are able to read.	Passed
Quiz data reading module	User id with quiz id	Quiz data should be retrieved from the database.	Data belonging to the particular quiz of a particular user.	Passed
User knowledge/ interaction data calculation module	Data belonging to the particular quiz of a particular user, including quiz data, interaction data and reading preference data.	Calculate user knowledge, interaction capability level and find user reading preferences.	User knowledge in different categories, interaction level and reading preference types.	Passed
User knowledge saving module	User knowledge, interaction capability level and reading preferences	Save data in a .csv sheet	Data saved in the .csv file	Passed
LM recommendation engine	User knowledge, interaction capability level and reading preferences from the saved .csv files	Should provide learning material recommendations	Provide learning material recommendations	Passed
Feedback generating module	Learning material recommendations, user profile	Should provide personalized feedback	Provide personalized feedback	Passed

Table 7.2: Summary of unit and integration testing (Self composed)

7.6. Non-Functional Requirements Testing

7.6.1. Accuracy Testing

The main nonfunctional requirement of the proposed solution is the accuracy of the learning material recommendations provided to the online assessment users. During the requirement identification phase, it was identified that a newly registered student should be provided with an accuracy above 40% and for an already registered student who has considerably interacted with the system with an accuracy above 70%. The accuracy of the recommendations was determined by using the equation as recommended by Lindgaard and Chattratichart, in 2007.

$$Accuracy\ perecentage\ of\ the\ output = \frac{Number\ of\ passed\ recommended\ data}{Number\ of\ recommended\ data} * 100$$

The accuracy of the recommendations was mainly tested based on 3 main criteria. They are:

- Recommendations provided for a user as a whole output against the set of topics
- Recommendation provided for a user for each topic
- Hybrid approach compared with CBF and CF

The below sections will analyze the test results obtained through the above mentioned testing approaches.

7.6.1.1. Accuracy of the Recommendations Provided for a User as a Whole Output Against the Set of Topics

To test the accuracy of the recommendations, ten distinct users were added to the system by the admin and they were asked to access the elaborated feedback generating system for 6 days where they were asked to perform 15 interactions with the system per a day. Then at the end of each day an accuracy rate of each user was calculated based on the above mentioned equation. Below figure 7.1 shows the statistics of the accuracy of the testing performed in the Elaborated Feedback Generator.

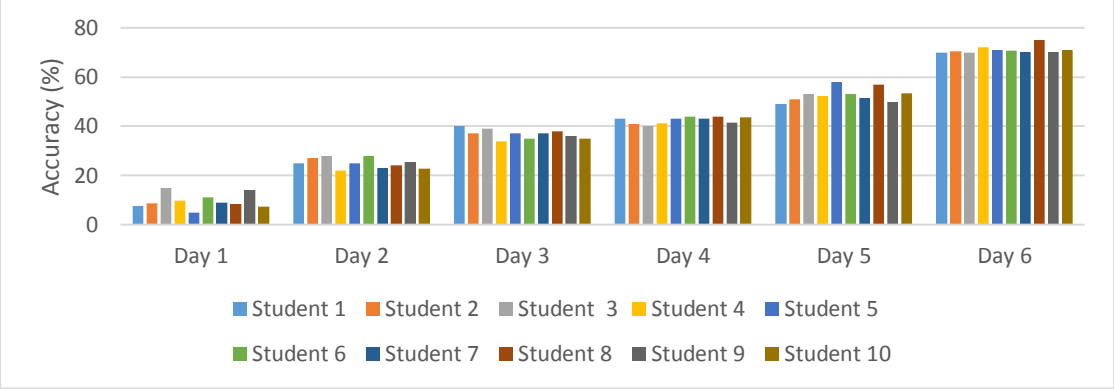

Figure 7.1: Accuracy rate of recommendations as a whole (Self composed)

With the statistics of the above figure it is displayed that the initial accuracy rate was very low. But as the learners interact more with the system, the accuracy rate of the recommendations gradually increases and have achieved the expected accuracy rate of above 70%. In order to achieve an accuracy of at least a 40%, it would take around 4 days or minimum of 60 interactions with the system.

7.6.1.2. Accuracy of the Recommendations Provided for a User for Each Topic

To test the accuracy of recommendations for each topic a user was selected and asked to perform 15 interactions per a day for 6 days. Then at the end of each day each recommended learning material was compared with the topic to check its accuracy.

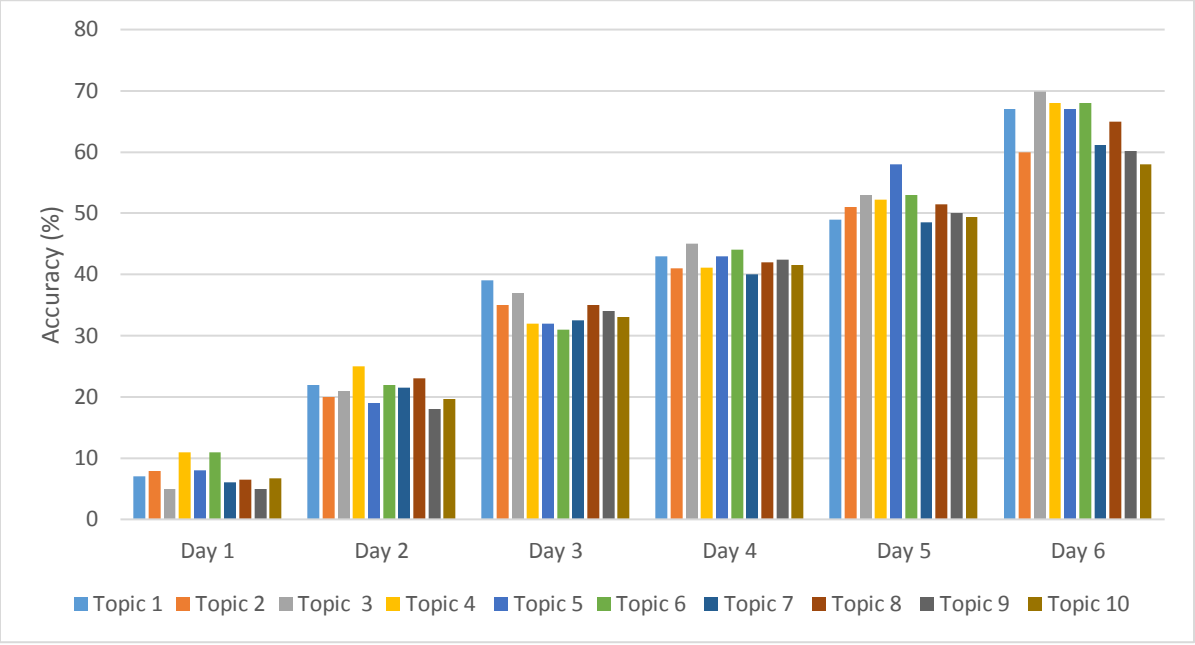

Figure 7.2: Accuracy rate of recommendations by topic

With the statistics of the above figure it is displayed that the initial accuracy rate was very low as same as the previous and as the learners interact more with the system, the accuracy rate of the recommendations gradually increases and have achieved the accuracy rate of nearly 60% - 70%.

7.6.1.3. Comparing the Hybrid Recommendation Approach with CBF and CF

Another testing was conducted to compare the hybrid recommendation approach against the CBF and CF. A set of another ten distinct users were selected and were allowed to access the system with the above 3 recommendation types for 5 days where they were asked to perform 15 interactions with the system per day. The averages of each approach were calculated for every day and was analyzed. Below figure 7.2 displays the statistics of the accuracy rate of recommendation approaches.

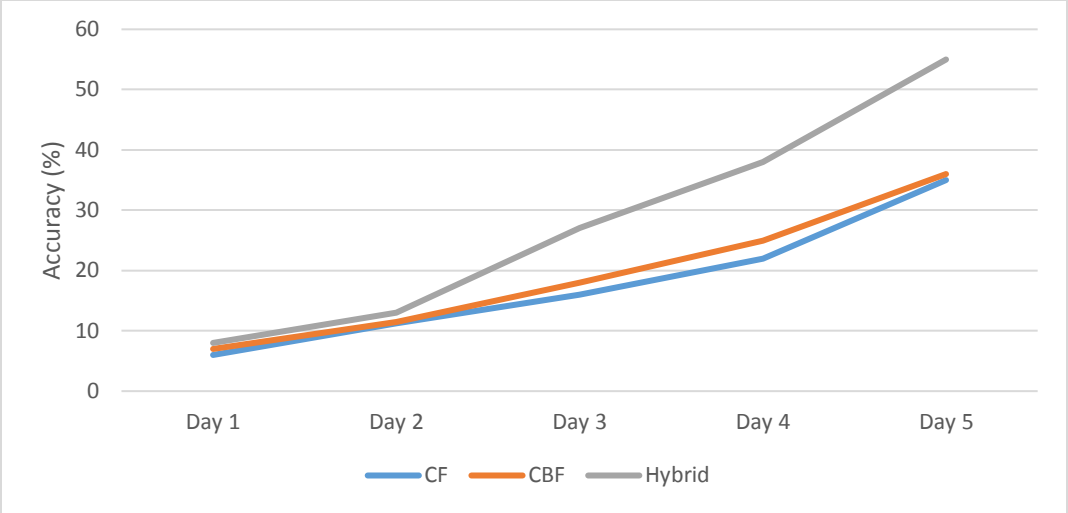

Figure 7.3: Accuracy rate of recommendation approaches (Self composed)

With the above mentioned statistics in can be seen that the hybrid recommendation approach provides a higher accuracy rate compared to the CBF or CF. According to the above graph the content based filtering approach provides a better accuracy compared to the collaborative approach. It may be due to the fact that at the time of the testing the system doesn't have enough readers to cluster them more logically.

7.6.2. Performance Testing

A performance testing of the Elaborated Feedback Generator was carried out to test the response time of the system and the below table 7.3 displays the statistics of the performance testing process carried out using a standard web browser and each test case was executed for 15 times and the average time was taken for the analysis.

Test case	Purpose	Input data	Expected result	Actual result (s)	Comment
1	Loading the home page for the 1st time	NA	3 sec or less	1.80	Pass
2	Logout from the website	NA	3 sec or less	2.85	Pass
3	Login to the website	User name and the password	3 sec or less	4.15	Pass
4	Submit answers of an assessment and get feedback	Question answers	5 sec or less	4.16	Pass
5	Get feedback of an already submitted assessment	User id and quiz id	3 sec or less	2.04	Pass

Table 7.3: - Performance testing of the system using a web browser (Self composed)

Rusu, et al (2011) has mentioned that the average load time of a webpage should be between one to seven seconds and the main page should be loaded around 2.45 seconds. As displayed in the above table time taken to load the main page of the system is less than 2.45 seconds and other interactions were performed below the expected time limit and it can be concluded that the system has a good response speed for user requests. Although the performance testing results were positive, it has to be noted that the testing was not carried out on an actual client- server network where other network devices might affect the latency of the requests and responses.

7.6.3. Load and Scalability Testing

Load and scalability testing is used to test the level and efficiency a system would be handling the load and the resources allocated to the system. Apache Benchmark is one of widely used load and scalability testing tool because of its ease of use and presentation of results. Therefore, the Apache Benchmark tool was used in order to test the load and scalability of the Elaborated Feedback Generator system where the system was running on a machine with an i7 processor of 2.40 GHz and 12GB of RAM and Windows 10 64bit version as the operating system.

Below mentioned are the statistics derived from the Apache Benchmark tool for the load testing carried out.

- Total data transferred is 571000 bytes for 1000 requests. Which is close to 517 per page and it is in line with the value of home page size.
- Test completed in 12.270s.
- Requests per seconds were 81.50.
- Time per request was 12269.823 ms (for 1000 concurrent requests). So across all requests it is 12269.823 ms/1000 = 12.270ms
- Transfer rate is received as: 45.45 (Kbytes/sec).
- In connection time stats, there were many requests had to wait for a few seconds. This may be due to apache putting requests in wait the queue.

When analyzing the results of the load testing, it can be concluded that the Elaborated Feedback Generator is able to handle at least 1000 users at a time, which can be considered as an acceptable rate for load and scalability testing. In addition to this, load testing was done by connecting and disconnecting the local host connection and noticed that the system operates in a normal way.

7.7. Limitations of the Testing Process

1. **Testing was not carried out on a real client server environment**

Performance testing was carried out by using a web server running on the same network as the client machines. Due to this the performance valued obtained may not represent the actual performance values as the real world networking of clients may negatively impact on the system performance.

2. Not enough time for the system to mature

One of the main requirements of the collaborative filtering is that the system should be matured with a large number of users and LM to produce more accurate recommendations. But the system does not have enough time and users to mature. Due to this reason the collaborative filtering may not produce accurate results accepted by collaborative filtering approach.

7.8. Chapter Summary

The chapter focused on the testing phase of the prototype. The chapter begun with discussing the purpose of the testing phase, testing criteria, testing methods and testing levels. It was identified that there are 2 main types of testing methods as software functional quality testing and software structural quality testing. Under software functional quality testing, functional requirement testing and unit and integrating testing were carried out using the black box testing method. According to the testing results, it can be concluded that the functional quality testing was successful with results with the expected level. Then the software structural quality testing was conducted and the nonfunctional requirements are tested. Testing of the performance, accuracy, load and scalability of the prototype were carried out under software structural quality testing phase. Overall software structural quality testing phase was also provided positive results. The next chapter is on evaluating the prototype.

Elaborated Feedback Generator

Chapter 8: Evaluation

- Chapter Overview
- Evaluation Criteria
- Selection of Evaluators
- Evaluation Methodology and Approach
- Summary of Evaluation Survey Questions
- Evaluation of Survey Findings
- Self-Evaluation
- Chapter Summary

8.1. Chapter Overview

The previous chapter discussed about the testing phase of the Elaborated Feedback Generator in order to make sure all the implemented functional and non-functional requirements developed are met with the expected level of goals. This chapter will discuss about the evaluation phase carried out with evaluators on different evaluation criteria and the self-evaluation conducted in order to find the strengths and weakness of the Elaborated Feedback Generator.

8.2. Evaluation Criteria

The criteria given in the below table 8.1 were the identified criteria for the evaluation process and they were selected with the aim of covering the major area of the project.

Criteria	**Description and purpose**
Overall concept and whole project	Elaborated Feedback Generator should obtain comments, views and evaluation with constructive criticism on the perception of the concept.
Scope and depth of the project	Since the recommending learning materials concept is broad, it is vital to get views and evaluate about the scope of the project with domain experts.
System design, architecture and implementation	Evaluate the design, architecture and implementation of each module whether they are completed properly by providing proper justifications.
Solution and prototype	Evaluate the prototype to determine whether the prototype acts as a proof of concept of the Elaborated Feedback Generator.
Knowledge calculation, interaction level calculation algorithms with LSM identification method	Evaluate the novel algorithms written to calculate knowledge, interaction level and to identify the LSM of the users.
Usability, performance and accuracy of the prototype	Evaluate the non-functional requirements of the Elaborated Feedback Generator to determine the level which the non-functional requirements are implemented.
Recommendation engine	Evaluate the effectiveness and suitability of the proposed recommender engine for the hypothesis.
Limitations of the solution and future enhancements	Identify the limitations and the possible future enhancements of the Elaborated Feedback Generator.

Table 8.1: Evaluation criteria (Self composed)

8.3. Selection of Evaluators

The below table describes the identified evaluator categories for the evaluation of the proposed solution and a high priority is given to the domain experts of e-learning who also have a knowledge in recommendation systems as the project weight goes to learning material recommendations and the end users of the system.

Evaluator category	Description & criteria evaluated
End users	A group of e-learning students and tutors were selected for the evaluation of the overall concept, usability, performance, accuracy, prototype and future enhancements criteria of the Elaborated Feedback Generator.
E-learning industry experts	A group of experts who are well experienced and currently working in e-learning industry were selected to evaluate the overall concept, prototype and future enhancement criteria.
Software engineers & architects	A group of well experienced software engineers and architects were selected to evaluate the system design, architecture, implementation and the future enhancement criteria.
Domain experts of recommendation systems	A group of experts on the recommendation system domain was selected to evaluate the recommendation engine future enhancement criteria of the recommendations.

Table 8.2: Evaluator groups (Self composed)

8.4. Evaluation Methodology and Approach

Evaluation phase is the assessment of an ongoing or completed project, programme or policy, its design, implementation and results with the aim of determining the relevance and fulfilment of objectives, efficiency, effectiveness, impact and sustainability (UNODC, 2016). The proposed solution was evaluated both quantitative and qualitative. Since the quantitative evaluation was almost achieved through the testing phase, in this chapter more importance was given to the qualitative evaluation of the project. Evaluation of the proposed solution was carried out thorough both interviews and the questionnaire, but the questionnaire was executed more due to the time limit had by the end of the project.

Evaluation methodology	Evaluator category	Description
Questionnaire	Experts of recommendation systems	Qualitative measuring of the recommendation algorithms by giving the source code, design and the implementation chapters.

Questionnaire	Software engineers and architects	Qualitative measuring of the design, architecture and implementation of the Elaborated Feedback Generator.
Questionnaire	End users of the system	Qualitative and Quantitative measures the non-functional requirements and the overall concept of the project.
Interview/ Questionnaire	Domain experts of e-learning	Qualitative measures the aspect of the overall concept, scope as well as the prototype.

Table 8.3: Evaluation methodologies (Self composed)

8.5. Summary of Evaluation Survey Questions

The below table 8.4 provides a summary of the questions used for the evaluation process.

No	Question
User related questions	
1	How many years of experience do you have in recommendation systems?
2	How many years of experience do you have in e-learning systems?
The project concept and the project as a whole	
3	What is your general idea about the Elaborated Feedback Generator system?
4	What would be the impact this solution would have on the selected user groups?
Scope and depth of the project	
5	Do you think the scope of the project is acceptable for graduate level?
6	What depth the solution should have addressed the recommendation systems?
System design, architecture and implementation	
7	What are your explanations about the design and architecture with regards to the project concept?
8	Do you think the decisions made in the implementation phase are acceptable and justifiable?
9	What are your suggestions on the design and the implementation?
The solution and prototype	
10	Do you think the presented solution is having the depth in solving the problem?
11	Do you think the system provides a solution to the identified problem?
12	What are your comments on the features offered?
Usability, performance and accuracy of the prototype	
13	How would you rate the usability, performance and accuracy of the prototype?
Recommender Engine	

14	What is your opinion on the hybrid approach used in the proposed solution?
15	What are the areas that have to be improved in the presented recommender engine?
Limitations of the solution and future enhancements	
16	What are the general limitations you see in the solution and what are your recommendations for those?
17	What are the features do you think can be added to proposed solution?

Table 8.4: Evaluation survey questions (Self composed)

8.6. Evaluation of Survey Findings

The evaluation results are presented as a summary including the comments and feedback of the evaluators.

7.8.1. Overall Concept

"Your project seems interested. I strongly believe that an intelligent, accurate recommendation system has a great potential and your project holds it."

Dr Antonis Michalas (PhD)

Assistant Professor, Head of Cyber Security Group, Department of Computer Science, Faculty of Science & Technology, University of Westminster

Evaluation module	**Summary of feedback**
The concept	The overall concept was appreciated by the evaluators. The lecturers who use e-learning systems to assess students were happy with the solution since: • Data overloading is one of the biggest problems in the selected domain and the proposed solution is solving the problem. • They do not want to recommend learning material personally to each student when they use the system and it saves their time giving feedback.
Review of the feedback	Considering mapping knowledge with the recommendations is a functionality which lacks while recommending learning materials and the solution will affect positively mostly on universities/colleges which provides online assessments for the students. Most of the evaluators mentioned that it is an interesting research and the project has the potential for success.

Table 8.5: Summary of evaluation feedback on the concept of the solution (Self composed)

7.8.2. Scope & Depth of the Project

"The scope is enough for a graduate level project"

Dr Srinath Perera (PhD)

Vice President of Research at WSO2 Inc.

"The research content proves that the project depth is enough for the graduate level."

Dr Olfa Nasraoui (PhD)

Director, Knowledge Discovery & Web Mining Lab, Dept. of Computer Engineering & Computer Science, Speed School of Engineering, University of Louisville

Evaluation module	**Summary of feedback**
The scope	The project scope met with the depth and challenge enough for a graduate level research and the selected research domain have the potential to include many enhancements with the time.
Review of the feedback	Recommendation systems are a board area to study with a huge depth. With the feedback from the experts it can be concluded that the depth is matched with a graduate level research.

Table 8.6: Summary of evaluation feedback on the scope of the project (Self composed)

7.8.3. System Design, Architecture and Implementation

"It is a good practice that you have used three tier architecture."

Dr Srinath Perera (PhD)

Vice President of Research at WSO2 Inc.

"You have selected REST and yes, it is a good option."

Dr Olfa Nasraoui (PhD)

Director, Knowledge Discovery & Web Mining Lab, Dept. of Computer Engineering & Computer Science, Speed School of Engineering, University of Louisville

Evaluation module	**Summary of feedback**

System design	Reviewers were satisfied with the design methodology with the design goals and decisions that were taken during the designing phase.
Review of the feedback	OOADM was selected since it is the best approach that can be followed with Java.
Evaluation module	**Summary of feedback**
System architecture	Architecture was accepted by almost all the reviewers.
Review of the feedback	The three tier architecture was used to implement the system and it can be concluded that it is acceptable for a graduate level project.
Evaluation module	**Summary of feedback**
Implementation	Most of the reviewers accepted that the technology selection was good and they are cutting edge technologies.
Review of the feedback	The technologies used for the implementation of the system were reviewed for their advantages and limitations and the most suitable technologies were chosen.

Table 8.7: Summary of system design, architecture and implementation feedback (Self composed)

7.8.4. Solution and Prototype

"Your solution seems to be addressing the problem. But it would be great if you can identify learner preferences implicitly only. Since explicit collection of learning preferences gives additional task for the end users. But it should be made in order to be more accurate than your hybrid approach."

Dr Olfa Nasraoui (PhD)

Director, Knowledge Discovery & Web Mining Lab, Dept. of Computer Engineering & Computer Science, Speed school of Engineering, University of Louisville

Evaluation module	**Summary of feedback**
Solution and prototype	Overall comment for the solution and prototype evaluation is that the solution presented and the prototype addresses the problem and tries to give a solution. But the evaluators have raised concerns over the approaches of identifying learning style models to do it completely by implicit data without using the hybrid approach.
Review of the feedback	The current solution was made to solve the data overload problem in e-learning systems and due to time restrictions not all the factors affecting learning materials were not able to collect. Ex: The relationship between exam time and student marks. A separate research should be conducted to find it.

	Collecting data for identifying learning style model only by an implicit approach can be included as a future enhancement since the hybrid approach used does not provide a better accuracy than the implicit finding of LSM.

Table 8.8: Summary of solution and prototype feedback (Self composed)

7.8.5. Knowledge Calculation, Interaction Level Calculation Algorithms with LSM Identification Method

"Knowledge calculation is done in a manner where no harm is done to the original user grading and the user knowledge breakdown seems an appropriate breakdown and the number of parameters are at an acceptable level. But when calculating the interaction data there are can be more parameters to consider. Increasing the breakdown will increase the accuracy level."

Dr Olfa Nasraoui (PhD)

Director, Knowledge Discovery & Web Mining Lab, Dept. of Computer Engineering & Computer Science, Speed school of Engineering, University of Louisville

Evaluation module	**Summary of feedback**
Knowledge calculation, interaction level calculation algorithms with LSM identification method	Overall commend about the algorithms written were positive except few evaluators asked to consider more interaction parameters while recommending LM.
Review of the feedback	The algorithms were written without harming the natural patterns of user data and the consideration of more interaction parameters while generating feedback can be included as a future enhancement.

Table 8.9: Summary of knowledge calculation, interaction level calculation algorithms with LSM identification method feedback (Self composed)

7.8.6. Usability Accuracy and Performance

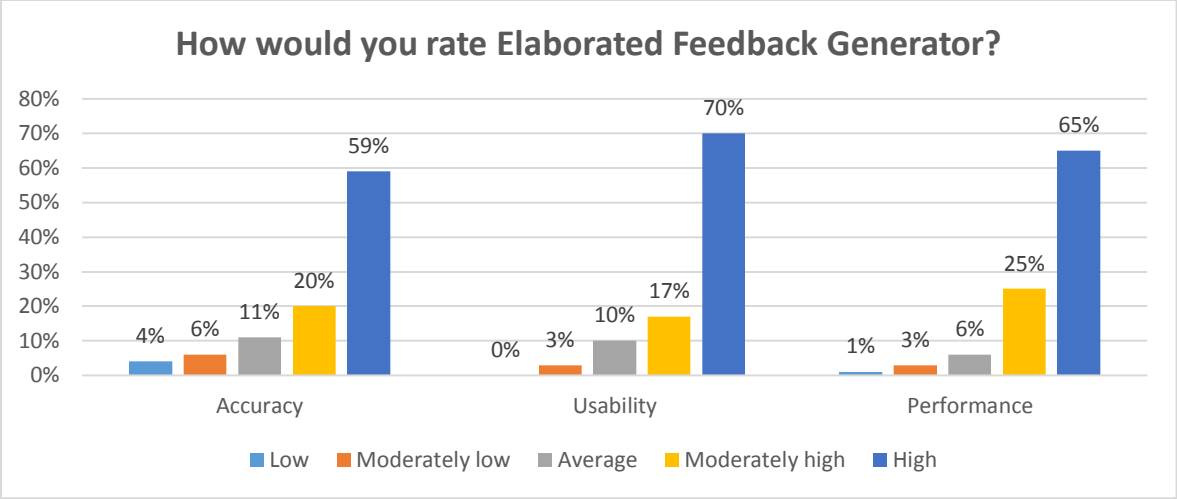

Figure 8.1: Achievement of non-functional requirements (Self composed)

The above figure 8.1 shows that the end users are satisfied with the non-functional requirements of the Elaborated Feedback Generator and all the evaluated non-functional requirements have met with high or moderately high satisfactory level by nearly 80%.

7.8.7. Recommendation Engine

"Use of the hybrid approach seems a better idea and using the item based collaborative approach rather than the user based can be considered as a good approach."

Dr Olfa Nasraoui (PhD)

Director, Knowledge Discovery & Web Mining Lab, Dept. of Computer Engineering & Computer Science, Speed school of Engineering, University of Louisville

Evaluation module	Summary of feedback
Recommendation engine	Most of the reviewers agreed with the selection of recommendation algorithms and use of Weka for machine learning.
Review of the feedback	The recommendation algorithms, techniques and libraries were selected from the literature survey conducted and with the help of domain experts. So that it can be concluded that the recommendation techniques, algorithms and libraries used are acceptable for a graduate level project.

Table 8.10: Review on evaluation of recommendation engine feedback (Self composed)

7.8.8. Limitations of the Solution and Future Enhancements

"Try to find the relationship between the question answering order and the knowledge level. If you can find a relationship, it could help to make the recommendations more accurate".

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Identified future enhancements are discussed in the conclusion chapter. Please refer to chapter 9.7 for detailed discussion of the future enhancements.

8.7. Self-Evaluation

The below table contains the self-evaluation on the identified evaluation criteria.

Criteria	**Self-evaluation**
Overall concept	The selected research area is a timely research with a good business perspective. So that providing a solution for such domain can be considered as a success. The concept could have further improved by considering privacy-preserving feedback generation approach.
Scope and depth of the project	Although the recommendation system domain is a wide area with a considerable depth, the proposed solution has the depth to a satisfactory level for the graduate level.
System design, architecture and implementation	The design approach used with the design goals and the system architecture are industry recognized standards. The prototype was developed in order to achieve the maximum level of accuracy with the given time frame. The techniques and technologies which were used during the implementation were critically evaluated cutting edge techniques and technologies. Therefore, it can be satisfied with the implementation of the Elaborated Feedback Generator.
Solution and Prototype	The prototype provides a solution to the information overload problem if the provided learning materials are accurate and matched with user preferences. The solution presents a novel approach of recommending learning materials to users considering their knowledge and the learning style model with other interaction data. The prototype can be considered user friendly and provides a better user experience except the explicit collection of data to find the learning style model which gives an

	additional task to the user. But it was used to improve the accuracy of identifying the learning style model.
Knowledge calculation, interaction level calculation algorithms with LSM identification method	The knowledge of a user for a particular topic was breakdown into many sub categories and found the knowledge level of the user. It is same with the interaction parameters too. In order to identify the LSM, FSLSM index and user history was considered. The accuracy of the recommendations is depending on these factors and as the recommendations have a high accuracy rate it can be concluded that these algorithms written are valid.
Usability, performance and accuracy of the prototype	The non-functional requirements were identified in order to achieve a higher level of accuracy. The non-functional requirements were identified through the requirements elicitation process. The current accuracy rate of the recommendations will be further improved with time as the system gets matured day by day with more data. Usability and performance of the Elaborated Feedback Generator were achieved to an exceptional level.
Recommender Engine	According to the testing results, the recommendation module provides an accuracy near 70%. So that the recommendation engine used for the Elaborated Feedback Generator can be classified as an achievement and valued solution for the problem. During the testing phase it was found that the collaborating filtering did not provide the expected accuracy rate due to the less maturity of the system.

Table 8.11: Self-evaluation of evaluation criteria (Self composed)

7.8.9. Reflection of the Functional Requirements

The below table 8.11 displays a reflection of the functional requirements and the priority levels mentioned in the table are based on the priority levels provided in the table 4.17.

Functional requirement	**Priority**	**Status**
Any registered user should be able to login to the system using his/her username and password and the system should authenticate the user.	C	Implemented
Student should be presented with a questionnaire to identify the learning style model.	C	Implemented
User should be able to view the feedback created at the end of the questionnaire, which is personalized to him based on personalizing criteria.	C	Implemented
User should be able view recommended learning material.	C	Implemented

System should generate feedback with learning material recommendations.	C	Implemented
If the authentication fails, the system should display an error message to the user, citing the reason for the authentication failure	I	Implemented
A tutor/teacher should be able to create courses after login.	I	Implemented
A tutor/teacher should be able to add assessments to the system after login.	I	Implemented
A tutor/teacher should be able to add questions and marking scheme for the assessments.	I	Implemented
Admin should be able to enroll the students to courses	I	Implemented
A student should be able to do assessments of the enrolled courses.	I	Implemented
The student should have completed the learning style model identification quiz to get recommended LM.	I	Partially implemented
Admin should be able to create accounts for the students/tutors and add them to the system.	L	Implemented
System should save the feedback generated.	L	Implemented
If the student has not answered the learning style model identification quiz, an error message should be displayed.	L	Partially implemented

Table 8.12:Reflection of functional requirements (Self composed)

Many problems were faced during the project life cycle and there are successes and failures as well. To overcome the problems faced a large number of research material were referred and gained guidance from domain experts too. The project plan had to be revised several times in order to align for the timeline provided. But from the perspective of the researcher, the project was a success. When comparing the proposed solution with the existing solutions, the proposed solution was researched, designed and developed specifically to achieve the highest possible level of accuracy of learning material recommendations. The testing and domain expert evaluations have valued the effort taken and there is a set of few future enhancements that can be incorporated to the proposed solution which will increase the user experience and accuracy of the recommendations.

8.8. Chapter Summary

The chapter started with describing evaluation criteria, evaluation methodology and selected different types of evaluators to evaluate the different phases of the proposed system with the justifications. Questionnaire and Interviews were selected as the evaluation approaches followed by reviewing the evaluation feedbacks. According to the feedback it was concluded that the concept of the project is timely and most of the evaluators valued the effort taken appreciating trying to create a relationship between user knowledge and

learning material recommendations. From the feedback received for the scope of the project, it was mentioned that the scope and the depth is acceptable for a graduate level project. The evaluators were also happy with the design along with the design goals, decision and the selection of technologies for the implementation. The evaluators gave a positive feedback towards selection of a hybrid approach for recommendations and the achievement of non-functional requirements of the Elaborated Feedback Generator. Several negative comments from the reviewers challenged with valid reasons and some were identified as potential future enhancements. The chapter concludes with a self-evaluation covering all the aspects of the proposed solution. The next chapter will be the conclusion chapter.

Elaborated Feedback Generator

Chapter 9: Conclusion

- Chapter Overview
- Achievement of Aim and Objectives
- Utilizing of Knowledge from Course Modules
- Use of Existing Skills
- Learning Outcomes
- Problems and Challenges Faced
- Limitations of the Research
- Future Enhancements
- Contribution
- Concluding Remarks

9.1. Chapter Overview

The previous chapter discussed the results obtained via the evaluation process of the Elaborated Feedback Generator. This chapter discusses about the concluding of the project by highlighting the achieving of aim and objectives, the problems and challenges faced during the project development phase, limitations of the project, identified future enhancements and closing remarks.

9.2. Achievement of Aim and Objectives

9.2.1. Aim

To design, develop and evaluate an online assessment feedback system with adapted feedback which recommends learning material to reduce the lack of interaction problem and information overload problem in e-learning systems.

The aim was successfully achieved with in the given time period and the prototype was qualitatively and quantitatively evaluated through domain experts, end users and self-evaluation process.

9.2.2. Objectives

Objective 1:	**Prepare terms of reference**
The terms of reference defined the aim and the objectives of the proposed solution along with an activity schedule which was used as a guideline for time management. TOR is included as the 1st chapter of the report.	
Objective 2:	**Project planning and management**
The project planning and management contains the selection of a project management methodology, selection of a development methodology and the risk analysis. The project planning is included as the 3rd chapter of the report.	
Objective 3:	**Conduct a literature survey**
The literature survey conducted provided a deep understanding about the e-learning systems which generate feedback with learning material recommendations, the various recommendation types with their design and the architecture with the positives and negatives of each approach which delivers the non-functional requirements of the existing solutions. It also paved a broader exposure on how the knowledge should be considered while providing learning material recommendations after an online exam/assessment. Literature survey is the 2nd chapter of the report.	
Objective 4:	**Requirement gathering**

Requirement gathering of the Elaborated Feedback Generator was done through end users, domain experts and self-evaluations and various requirement gathering techniques were employed to gather requirements. Information gathered through various requirement gathering techniques such as online surveys, interviews, and literature review was analyzed to identify the functional and non-functional requirements of the system. The 4th chapter contains about the requirements gathering of the proposed solution.	
Objective 5:	**Designing the prototype**
Designing of the system was carried out to satisfy the most appropriate techniques identified from the literature review and requirements identified through the requirement analysis. The prototype design is the 5th chapter of the report.	
Objective 6:	**Implementation**
Implementation was carried out using the factors identified in LR, SRS and design. A detailed description of the prototype development is included as the 6th chapter and the chapter contains the relevant code fragments and problems and solutions found during implementation phase.	
Objective 7:	**Testing the prototype**
The prototype was tested through a devised testing plan and testing was done in quantitative and qualitative aspects. The testing phase is described in the 7th chapter.	
Objective 8:	**Evaluation of the work carried out**
Evaluation of the project was carried out to evaluate the project using domain experts and self-critique. Then conduct a review of the evaluation findings to determine how far the project has successfully completed. Project evaluation is on chapter 8.	
Objective 9:	**Documentation and Submitting final prototype**
Documentation of each phase that was carried throughout the project life cycle was done with due thoroughness. Chapters from 1 to 9 contain the documentation of the each objective of the project.	

Table 9.1: Contribution of objectives towards the completion of the project (Self composed)

9.3. Utilizing of Knowledge from Course Modules

Although some of the modules learned during the degree program were not directly linked to the project research area, the knowledge and exposure got through those modules contributed positively towards the successful completion of the project. The following modules described in the below table 9.2 were distinguished by providing significant contributions to the project completion.

Module	Contribution

Requirements Engineering	Requirements Engineering module helped to conduct the requirements specification phase by identifying the stakeholders and conducting requirements elicitation by the selected elicitation methods.
Software Quality and Testing	Software Quality and Testing module helped to conduct the testing phase of the project. The non-functional and functional requirements were tested from the knowledge gained through the module.
Database Design	The knowledge gain through the module was helpful when creating the database while implementation.
Information and Data Modelling	The knowledge for drawing UML diagrams were obtained through this module.
Project Management	Project management module helped to plan the project timeline, resources, and deliverables and to came up with a risk mitigation plan.

Table 9.2: Contribution of modules towards the completion of the project (Self composed)

9.4. Use of Existing Skills

Existing programming skills on the Java platform were helpful and those skills were successfully utilized for the completion of the project.

9.5. Learning Outcomes

- Though the course content offered during the degree program provided knowledge on various software engineering related topics, they didn't cover about the recommendation systems/algorithms which is the basic foundation of the project. Therefore, self-learning via online documents/tutorials and knowledge transfer sessions with domain experts were used to gain the necessary knowledge to complete this project.
- Key technologies such as the Weka machine learning library was self learnt through online documentations and tutorials for the successful completion of the project.
- Critical thinking and formal documentation skills were developed through gradual learning and hands on experience.
- Plan and schedule own work aligning to the time frame.

It can be concluded that knowledge gained through the degree program, existing skills and self-learned skills combined resulted in the successful completion of the project.

9.6. Problems and Challenges Faced

- **The wide scope**

  The recommendation system domain is a very broad and deep area for a graduate level research. Then the literature level and requirement elicitation processes were used to scale down the project to match with the graduate level research.

- **Time Constraint**

  Being a research project the inherited risk of frequent requirement fluctuations and lack of domain knowledge threatened to overrun the time allocated to the project. But the use of spiral development approach provides the solution to the problem by having an iterative development process by supporting requirement fluctuations.

9.7. Limitations of the Research

Restriction on the key success factors of a recommendation system

The current research considered only about accuracy as the key success factor. But apart from accuracy there are various other key success factors such as scalability, privacy preserving and etc. for a recommendation system and this research can be further expanded to explore the accommodation of those left out key success factors while recommending learning materials.

Manually identification of learning material content types

The current research identifies the content of learning material manually. But the content can be identified by writing a program too. The manual identification was picked due to the time frame had to develop the prototype.

9.8. Future Enhancements

Enhancement ID	ENH1	**Priority Level**	High
Enhancement	Automatic detection of learning material content types		
Description	Currently the content type of the learning materials is found manually. But it can be developed to identify automatically by writing another module.		
Enhancement ID	ENH2	**Priority Level**	High
Enhancement	The recommendation engine should be made scalable and privacy preserving.		
Description	The scalability and privacy preserving are 2 main key success factors of a recommendation system. Including those non-functional requirements will act positively towards the final product.		
Enhancement ID	ENH3	**Priority Level**	High

Enhancement	The user answering order can be should be considered to generate learning material recommendations.		
Description	Consider the user answering order and the type of the area which a user prefers to answer first. This can be considered as an interaction parameter which will help to increase the accuracy of the recommendations.		
Enhancement ID	ENH4	**Priority Level**	Low
Enhancement	Expansion to a distributed system		
Description	The system can be enhanced to the level of a distributed system which would able handle the load of end users and learning materials in a more efficient manner with the use of both hardware and software level scalability.		

Table 9.3: Contribution of modules towards the completion of the project (Self composed)

9.9. Contribution

Elaborated Feedback Generator provides a solution to the overloaded information problem of the e-learning systems. Most of the online assessment systems does not consider about the main 3 factors: user knowledge, interaction data and user learning style model with user reading history in order to generate accurate learning material recommendations to students. There were few products which have considered user knowledge, but they lack the application of user knowledge level when providing LM recommendations. They have considered only the key word of the area which a user lacks knowledge. The proposed Elaborated Feedback Generator has contributed the e-learning systems by solving the information overload problem by providing accurate LM recommendations by introducing a novel way of mapping user knowledge with LM and by considering most of all the LM personalizing factors.

9.10. Concluding Remarks

The proposed solution presents a novel way of considering user knowledge to generate LM recommendations with considering other personalizing factors such as interaction data and user reading preferences with the history. The solution had taken the Moodle which is a widespread learning management system. The presented solution can be vastly beneficial for the e-learning domain to attract more users and to improve the student knowledge. The current solution opens up new research areas for the research community to further enhance the solution by trying out the future enhancements mentioned in the above table 9.3.

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Elaborated Feedback Generator

Appendix

Appendix A: Terms of Reference

1.1. Chapter Overview

The purpose of this chapter is to come to an agreement with the supervisory body about the outline of the project on the structure, main purpose with aim and objectives, plan and the requirements of the project.

This document briefly describes the factors that inspired the author to undertake the mentioned research project. It also includes the importance of doing it, an introduction about the online assessment feedback systems, previous work, the aim and objectives for successful completion of the project, features of the prototype, project deliverables and resource requirements.

1.2. Project Overview

1.2.1. Project Background

In traditional learning environment, teachers provide individual feedback to students in order to improve their knowledge and to motivate, based on the skills students show in a particular exam, students' personality and considering the day to day skills shown by the student. When it comes to e-learning, there is no role of a teacher. Many researchers have found that the lack of interaction between the teacher and the students is the main problem in online learning applications and this is a major concern in providing feedback in online assessments too.

Students test their knowledge through online assessments and get a feedback based on the answers they provided to a particular set of questions. So the "feedback in e-learning is the mechanism that tends to replace the teacher who provides comments, advice, and explanations and evaluates the students in traditional learning environments" (Vasilyeva et al., 2007).

The feedback given in an online assessment is the most important fact of influence to students to achieve the next step. It has been described as "the most powerful single moderator that enhances achievement" (Hattie, 1999). The feedback provided via an online assessment should fulfill the main objectives such as:

- Justify to students how their mark or grade was derived.
- Identify and reward specific qualities in student work.
- Guide students on what steps to take to improve

- Motivate them to act on their assessment
- Develop their capability to monitor, evaluate and regulate their own learning (Nicol, 2010)

Feedback is valuable when it is received, understood and acted on. How students analyze, discuss and act on feedback is as important as the quality of the feedback itself (Nicol, 2010). The properties of the feedback are important in applications with large user groups having a variety of individual characteristics and goals. Feedback adaptation offers possibilities to deliver feedback that is the most appropriate for the user's skill level, personal characteristics, mood, behavior, and attentiveness (Vasilyeva et al., 2008).

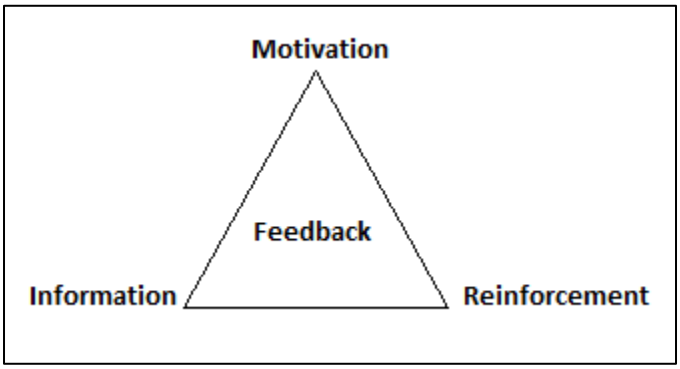


Figure A.1: Feedback Triad (Ekaterina, 2007)

As demonstrated in feedback triad (Figure 1.1), at the same time feedback should function as a motivator on the emotional level, reinforcement as a concept on the behavioral level and provider of information on the cognitive level of function or analysis. These levels are especially important in the e-learning systems.

1.2.2. Problem Domain

E-learning can provide better support for the less able, engage students who do not respond well to 'traditional' classroom learning, provide opportunity for accelerated learning for gifted and talented students, and develop independent learning skills through a personalized learning experience (Boulton, 2008). If the feedback is not fulfilling at least its main objectives, that assessment is not going to benefit the student or the e-learning system. The lack of full knowledge about student's cognitive ability, learning style and real time affect status are the problems in generating elaborated feedback.

Badly designed feedback or the lack of feedback could distract the student from learning, it could provoke the students to stop using the e-learning system or even to drop the course, even in blended learning. Well-designed and adapted or tailored feedback can help the learning process (Vasilyeva et al., 2008).

In order to reduce the information overload problem in e-learning applications, the feedback provided should be:

- Timely and constructive
- Show real world implications to encourage change.
- Focus on skills or behaviors that can be altered.
- Encourage group eLearning feedback through collaborative exercises.
- Tie e-learning feedback into objectives and goals (Pappas, 2014).

To provide feedback with above features, the user characteristics such as below can be considered:

- Knowledge
    - Background, Experience, Goals, etc.
- Personal Data
    - Age, Culture, Attention, Memory, etc.
- Interaction parameters
    - Chronometric data, Try data, etc.

Although the importance of feedback adaption has been found, there hasn't been any completed software solutions for feedback adaption which fulfill at least the main objectives of online assessments. Therefore, an online assessment system is proposed with feedback adaption which fulfills main objectives of online assessments considering the tasks and the personality of a user to improve the quality of e-learning by providing a solution to overloaded information problem. The problem is addressed considering the software engineering students who tries to learn programming languages online and test their knowledge through online assessments.

1.2.3. Previous Work

Since it has been identified that the feedback adaption is important there are few pieces of research done on this area over the past decade.

Title and the Owner	Introduction	Features	Limitations	Future Work
Design of Self-directed e-Learning Material Recommendation System with On-line Evaluation by Liu and Feng-Jung (2008)	An ontology-based self-evaluation system with material recommendation system. The system is divided into 2 subsystems: Material recommendation subsystem and self-evaluation subsystem. In this material recommendation part, the system recommended the related content by analyzing previous learners' activities (Liu and Feng-Jung, 2008).	Recommend LM. Self-evaluation.	Does not matched with user knowledge. Only matched with user preferences	The system prototype has been established but not completed. So far, there are 28 URLs of courses registered in the recommendation system respectively. It contains about 574-course units in total. Each query request spends about 0.65 seconds (Liu and Feng-Jung, 2008).
Hybrid attribute-based recommender system for learning material using genetic algorithm and a multidimensional information model by Salehi,	Contains 2 main modules: **Explicit attribute based recommender** - Weights of implicit or latent attributes of materials for learner are considered as chromosomes in genetic algorithm then this algorithm optimizes the weights by historical rating. Then, recommendation is generated by NNA using the optimized weight vectors implicit attributes. **Implicit attribute based recommender** - PM is introduced that can model the interests of learner	Recommend LM.	Does not matched with user knowledge. Only matched with user preferences	Improve the recommendation process by hybrid approach and mine learner's historical access records for discovering the resource access sequential patterns. Then, using these sequential patterns, we can predict the most probable resource that a learner will access

Pourzaferani and Razavi (2013)	based on explicit attributes of LM in a multidimensional information model. Then, a new similarity measure between PMs is introduced and recommendations are generated by NNA (Salehi et al., 2013).			in near feature (Salehi et al., 2013).
Automatic Recommendations for E-Learning Personalization Based on Web Usage Mining Techniques and Information Retrieval by Khribi, Jemni, and Nasraoui (2013)	Recommended learning resources are computed based on the current learner's recent navigation history, as well as exploiting similarities and dissimilarities among learners' preferences and educational content. This contains 2 modules: **Off-line module** - Preprocesses data to build learner and content models. **Online module** - Uses these models on-the-fly to recognize the students' needs and goals, and predict a recommendation list. Recommended learning objects are obtained by using a range of recommendation strategies based mainly on content-based filtering and collaborative filtering approaches, each applied separately or in combination (Khribi et al., 2013).	Recommend LM.	User Interaction parameters have not considered while generating feedback.	Integrating educational preferences in the learner's model such as learning styles, media types, etc. The learner's model to should compose of three main components: learner's profile, learner's knowledge and learner's educational preferences (Khribi et al., 2013).

Table A.1: Previous work (Self composed)

As mentioned in the above table (Table 0.2), there are 3 main previous work identified and the feedback generated by those projects/products are generated considering the following user characteristics as shown below (Table 0.3).

Product/Project Name	**User characteristics concerned in generating elaborated feedback**		
	K**nowledge**	**Personal Data**	**Interaction Parameters**
Adaptation of Feedback in e-learning System at Individual and Group Level			✓
A Feedback Effectiveness Oriented Math Word Problem E-Tutor for E-Learning Environment	✓		✓
Gesture-based Affective and Cognitive States Recognition using Kinect for Effective Feedback during E-learning		✓	
Proposed solution	✓	✓	✓

Table A.2: User characteristics concerned in generating feedback (Self composed)

The proposed solution will generate feedback considering all possible individual user characteristics which influence on generating elaborated feedback.

1.3. Project Aim

To design, develop and evaluate an online assessment feedback system with adaptive feedback which recommends learning material to reduce the lack of interaction problem and information overload problem in e-learning systems.

Further elaborating the aim, this project will produce an online assessment feedback system with personalized and elaborated feedback with recommendations according to the following user characteristics.

- Knowledge
  - Ex: If the user is making the same mistake repeatedly the solution can generate feedback, including a detailed explanation of where the student went wrong. The feedback can be started with following the user's knowledge. Which means, of finding out which theories/concepts that the user is mastered
- Personal data
  - Ex: The feedback can be personalized according to the user name, gender, age, etc. The use of personal data is to give the user the feeling that it is personal to him. This is because it is the first thing which makes the user feel that the feedback is personalized.
- Interaction parameters
  - Ex: The number of attempts taken

    Time taken to refer related articles

The proposed solution will not cover adaption of feedback to a group of users or a stereotype.

1.4. Project Objectives

To archive the aim of the project some of the objectives are defined below:

Objective 1:	**Prepare terms of reference**
• Prepare the TOR document including the project background, problem domain, previous work, project aim, project objectives, features of the prototype, project deliverables, resource requirements and the project plan which will be a guide throughout the project life cycle. • Submit draft TOR. • Submit final TOR after evaluation. **Expected output artefact:** Terms of reference document	

Objective 2:	**Project planning and management**

- Conducting risk analysis
- Drawing work breakdown structure
- Writing activity schedule (grant chart)
- Selecting a software development methodology

  Selecting a recursive software development methodology which will be most suitable to carry out the different phases of the project in the recursive way.

Expected output artefact: Project planning and management chapter

Objective 3:	**Conduct literature survey**

Conduct in-depth literature survey in the following areas:

- Characteristics of feedback given from online assessment systems – To understand how the online assessment systems works and how relative the feedback given from those systems.
- Gain knowledge about what other individuals and organizations have found in the research area and how they tried to develop or design the solution – To understand the techniques, technologies and algorithms used in existing online assessment systems to provide feedback.
- Find out undiscovered problems and unresolved problems in online assessment feedback systems – To understand the problem domain.
- What can I do to fill up those gaps – To provide the solution.
- Different development technologies to determine the best approach to follow to fill those gaps.

Expected output artefact: Literature review document

Objective 4:	**Requirement gathering**

Carryout an in-depth user requirement gathering phase with:

- Selecting and justifying elicitation techniques
- Selecting and justifying analysis tools
- Execute elicitation techniques
  - ✓ End users of online assessment system users through a questionnaire and observation of online assessment systems to identify the end user requirements and behaviors.
  - ✓ Domain experts of online assessment feedback systems to identify the standards of online assessment feedback systems and current processes to provide feedback along with their suggestions to make feedback more appropriate.
  - ✓ Domain experts who have done previous researches about the importance of elaborated feedback.

- ✓ Personal evaluation of the existing online assessment feedback systems to verify the end user requirements and domain expert ideas and identify any possible new requirements.

- Analysis of requirements
- Documenting SRS
  - ✓ Using the data gathered through literature review, end user questionnaire and observations, domain expert interviews and personal evaluations prepare the software requirements specification to document the functional and non-functional requirements of the proposed system.

Expected output artefact: Software requirement specification document

Objective 5:	**Designing the prototype**

- Select the most appropriate technologies and tools to develop the proposed solution.
- Prepare the design specification for the prototype according to the analyzed requirements gathered in requirement gathering phase.

  Expected output artefact: Architecture Specification, Decision analysis reports

Objective 6:	**Implementation**

- Develop the prototype to full fill user requirements.

Expected output artefact: Software prototype

Objective 7:	**Testing the prototype**

- Create a test plan
- Create test cases
- Conduct in-depth testing of the system to identify bugs and check whether the required functional and non-functional requirements of the users are achieved from the developed prototype.
- Fix the bugs if there are any

Expected output artefact: Test results

Objective 8:	**Evaluation of the work carried out**

- Carry out a critical evaluation of the prototype using selected user groups of the system and conduct a review of the evaluation findings to determine how far the project has successfully addressed the hypothesis
- Carry out a review with domain experts of different research areas used in the prototype to identify areas for future improvements
- Perform a personal evaluation to self asses the work carried out

Expected output artefact: Review document	
Objective 9:	**Documentation and Submitting final prototype**
• Documenting key findings of the research • Documenting key steps involved in the project prototyping and testing • Submitting project proposal, interim project report, draft project report and bonded project report **Expected output artefact:** Final project report	

Table A.3: Project Objectives (Self composed)

1.5. Features of Prototype

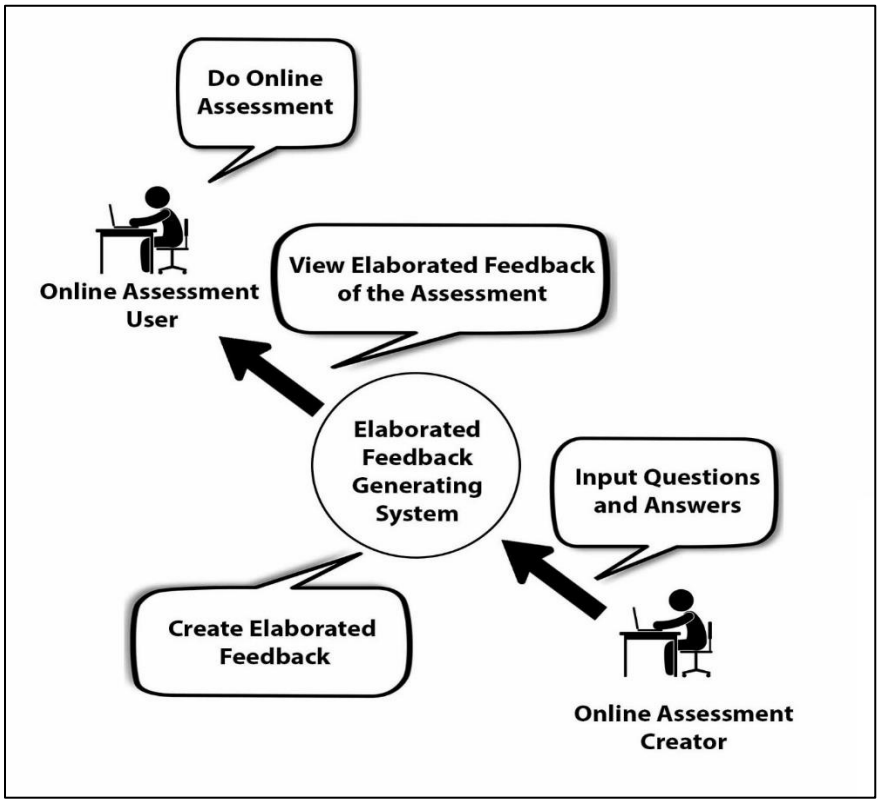


Figure A.2: Features of the Prototype (Self composed)

As shown above, the figure 1.2 shows the features of the prototype. Further they can be mentioned as below.

- Online assessment creator should allow creating an assignment
- Online assessment creator should enter answers for the questions
- Online assessment user should allow doing the assessment
- System should create elaborated feedback to a particular user according to the answers provided by the user

- Online assessment user should present with an elaborated feedback

1.6. Project Deliverables

- Draft Terms of Reference
- Terms of Reference
- Literature Review
- Requirement Specification
- Software Design Document
- Interim Report
- Prototype Report
- Draft Project Report
- Project Report
- Project Prototype

1.7. Resource Requirements

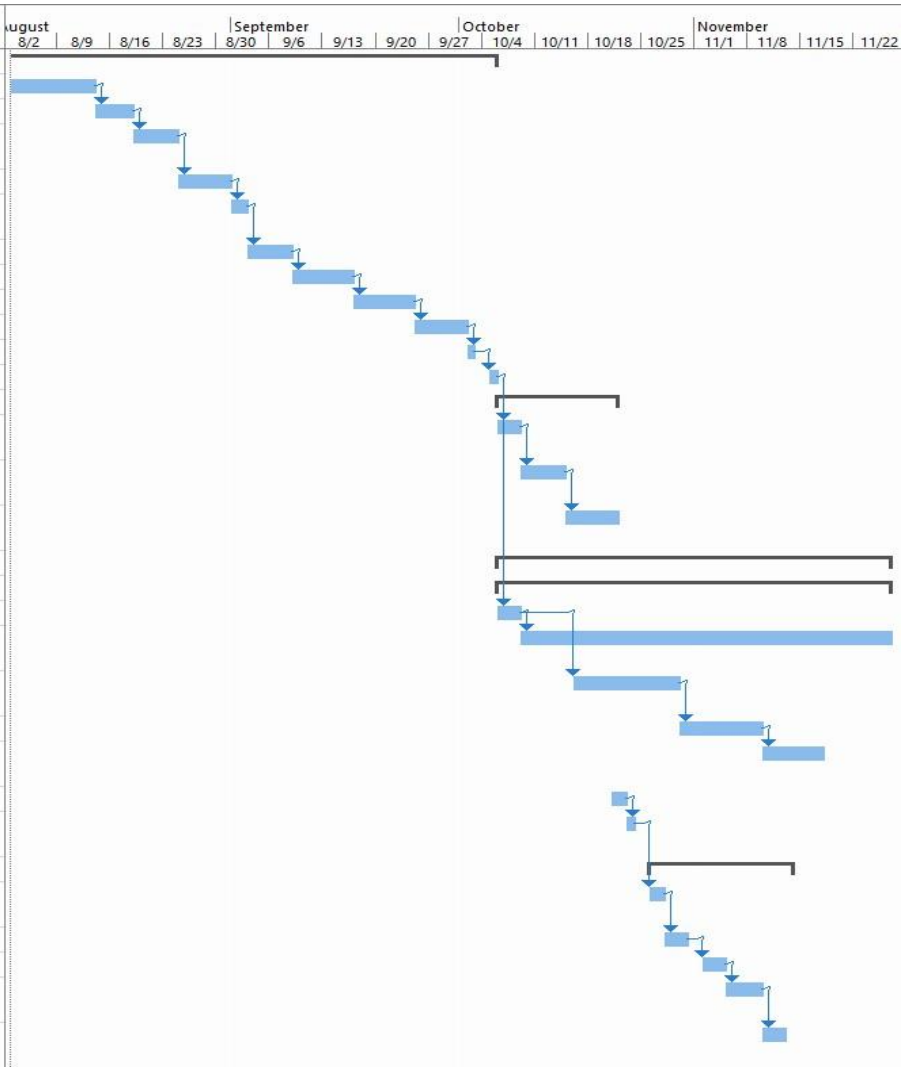
* The resource requirements are subjected to changes.

Hardware Requirements	Software Requirements
• Core i5 2.13 GHz processor • 4 MB DDR3 RAM	• Online assessment creation tool • Recommendation engine • Java SDK 1.6 • PHP • Java Script • IntelliJ IDEA • Microsoft Office package for documenting the report • Rational Rose for documenting the design

Table A.4: Resource Requirements (Self composed)

Appendix B: Activity Schedule

ID	Task Mode	Task Name	Duration	Start	Finish
1		**Project initiation phase**	**46 days**	**Mon 8/3/15**	**Mon 10/5/15**
2		Identify the problem backgrouund	9 days	Mon 8/3/15	Thu 8/13/15
3		Identify key stakeholders	3 days	Fri 8/14/15	Tue 8/18/15
4		Gather requirements to define project scope	4 days	Wed 8/19/15	Mon 8/24/15
5		Analyse existing systems	5 days	Tue 8/25/15	Mon 8/31/15
6		Propose a solution for the identified problem	2 days	Tue 9/1/15	Wed 9/2/15
7		Define the project scope	4 days	Thu 9/3/15	Tue 9/8/15
8		Identify deliverables/expectations	6 days	Wed 9/9/15	Wed 9/16/15
9		Identify technical resources needec	6 days	Thu 9/17/15	Thu 9/24/15
10		Finalize all documents	5 days	Fri 9/25/15	Thu 10/1/15
11		Submit draft terms of reference	1 day	Fri 10/2/15	Fri 10/2/15
12		Submit final terms of reference	1 day	Mon 10/5/1	Mon 10/5/15
13		**Planning phase**	**12 days**	**Tue 10/6/15**	**Wed 10/21/15**
14		Identify the risks involve with the project	3 days	Tue 10/6/15	Thu 10/8/15
15		Determine the software development pprocess	4 days	Fri 10/9/15	Wed 10/14/15
16		Communicate change management process	5 days	Thu 10/15/15	Wed 10/21/15
17		**Documentation**	**38 days**	**Tue 10/6/15**	**Thu 11/26/15**
18		**Conduct literature review**	**38 days**	**Tue 10/6/15**	**Thu 11/26/15**
19		Surveying relevant literature	3 days	Tue 10/6/15	Thu 10/8/15
20		Literature review document formation	35 days	Fri 10/9/15	Thu 11/26/15
21		Sysnthesising literature formation	10 days	Fri 10/16/15	Thu 10/29/15
22		Identify areas of controversy	7 days	Fri 10/30/15	Mon 11/9/15
23		Formulate questions for future research	6 days	Tue 11/10/15	Tue 11/17/15
24		Finalize literature review	2 days	Wed 10/21/	Thu 10/22/15
25		Final literature review submission	1 day	Fri 10/23/15	Fri 10/23/15
26		**Conduct requirement analysis**	**15 days**	**Mon 10/26/**	**Fri 11/13/15**
27		Determine functional and non-functional requirements	2 days	Mon 10/26/15	Tue 10/27/15
28		Determine system requirements	3 days	Wed 10/28/	Fri 10/30/15
29		Determine skill requirements	3 days	Mon 11/2/1	Wed 11/4/15
30		Completion of requirements analysis	3 days	Thu 11/5/15	Mon 11/9/15
31		Construct requirement specification	3 days	Tue 11/10/15	Thu 11/12/15



ID	Task Mode	Task Name	Duration	Start	Finish
32		Submission of requirement specification	1 day	Fri 11/13/15	Fri 11/13/15
33		**Design and execution**	**75 days**	**Mon 11/16/**	**Fri 2/26/16**
34		**Design the project**	**7 days**	**Mon 11/16/**	**Tue 11/24/15**
35		Conceptual design	2 days	Mon 11/16/	Tue 11/17/15
36		Business logical design	2 days	Wed 11/18/	Thu 11/19/15
37		Internal design	2 days	Fri 11/20/15	Mon 11/23/15
38		Completion of system design	1 day	Tue 11/24/1	Tue 11/24/15
39		**Implementation**	**68 days**	**Wed 11/25/**	**Fri 2/26/16**
40		Environment setup	6 days	Wed 11/25/	Wed 12/2/15
41		Implement solution	54 days	Thu 12/3/15	Tue 2/16/16
42		Create test script	6 days	Thu 12/3/15	Thu 12/10/15
43		Completion of the prototype implementation	8 days	Wed 2/17/16	Fri 2/26/16
44		Construct project progress report	5 days	Wed 1/20/1	Tue 1/26/16
45		Submission of project progress report	1 day	Wed 1/27/16	Wed 1/27/16
46		**Testing phase and report compilation**	**91 days**	**Tue 11/24/1**	**Tue 3/29/16**
47		High level test plan development	4 days	Tue 11/24/1	Fri 11/27/15
48		User acceptance test	5 days	Mon 11/30/	Fri 12/4/15
49		Demonstration of prototype and submission of report on prototype	3 days	Wed 2/17/16	Fri 2/19/16
50		Preformance test	20 days	Thu 12/3/15	Wed 12/30/15
51		Analyse and evaluate defects of the system	25 days	Thu 12/31/15	Wed 2/3/16
52		Eliminate defects	20 days	Thu 2/4/16	Wed 3/2/16
53		Completion of testing	5 days	Thu 3/3/16	Wed 3/9/16
54		Project evaluation	7 days	Thu 3/10/16	Fri 3/18/16
55		Project report compilation	5 days	Mon 3/21/1	Fri 3/25/16
56		Deploy to production	2 days	Mon 3/28/1	Tue 3/29/16
57		**Project closure**	**18 days**	**Wed 3/30/1**	**Fri 4/22/16**
58		Application turn over to steady stat	2 days	Wed 3/30/1	Thu 3/31/16
59		Submission of draft project report	1 day	Fri 4/1/16	Fri 4/1/16
60		Document lessons learned	4 days	Mon 4/4/16	Thu 4/7/16
61		Prject completion	4 days	Fri 4/8/16	Wed 4/13/16
62		Submission of bound copies of the project reports	7 days	Thu 4/14/16	Fri 4/22/16

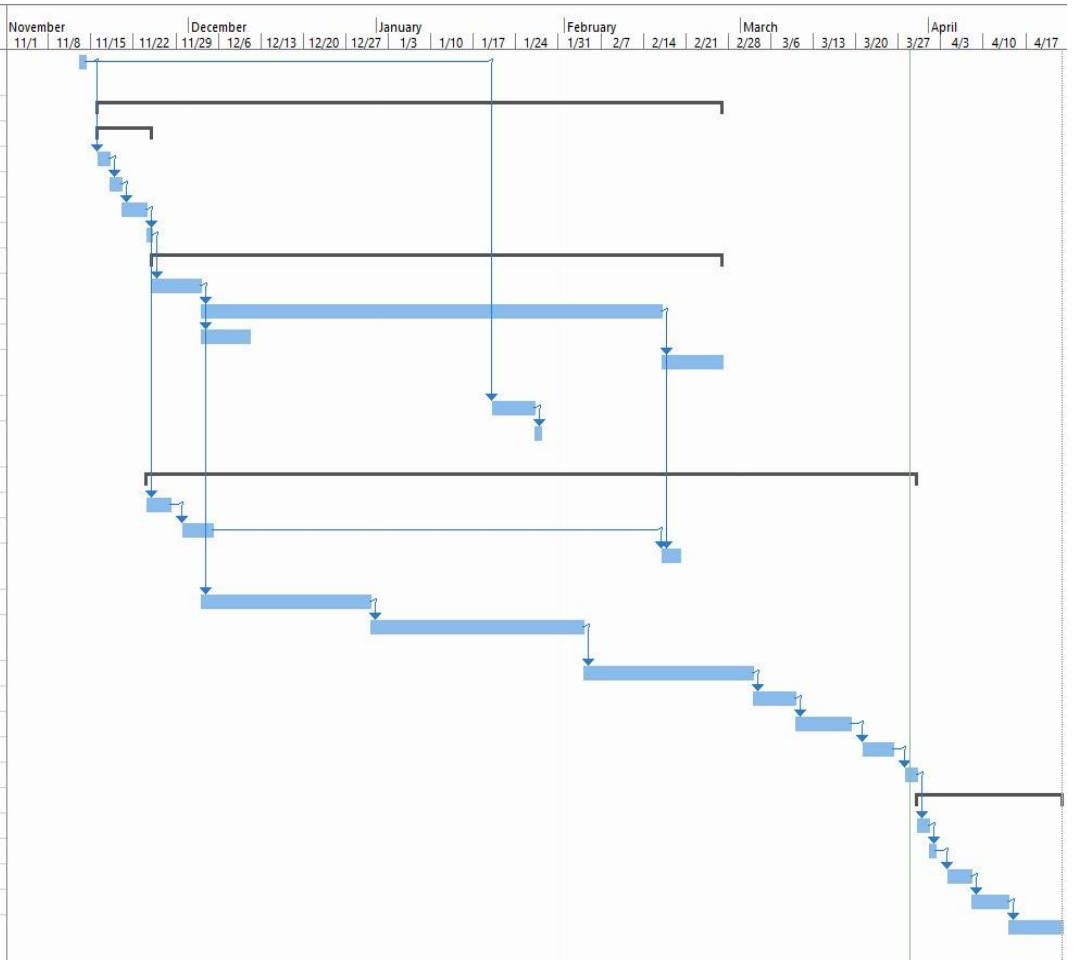


Figure B.1: Activity Schedule

Appendix C: Selection of a Development Methodology

In a research project requirements are subjected to change frequently. Since the linear model with rigid phases doesn't support requirement fluctuations of experimental and research development, the traditional waterfall method is not appropriate for a research project. When considering the Rapid Application Development methodology, it can be seen that it uses minimal planning and then moves into prototype development at an early stage of the project. It is evident that it is a must to have a certain level of understanding of the final products' functionalities to start developing the prototype at an early stage. So this methodology will also not work with a research project. Agile methodology is more suitable to handle projects with a huge scope and larger number of stakeholders at various levels of an organization. Since the project undertaken has a major constraint on the time availability and neither involved with a huge scope nor a larger number of stakeholders it can be concluded that Agile methodology is not suitable to handle the project in hand. Similar to the Rapid Application Development Methodology Prototype methodology also focus on moving into the development of the prototype at an early stage of the project and have the same. Additionally, it may increase the complexity of the system and may lead to scope enhancements of the system due to the higher rate of customer interaction leading to time overruns.

Appendix D: Stakeholder Roles

1.1. Beneficiary

1.1.1. Political Beneficiary

Stakeholder:	Viewpoint:
Minister of Education	When the system makes the life of the operation stakeholders easy, they get the advantages in elections.

Table D.1: Political Beneficiary (Self composed)

1.1.2. Purchasing

Stakeholder:	Viewpoint:
Learners	Learners will have to pay a small amount in order to experience all the features provided by elaborated feedback generating system. Only a limited number of features will be free.
Instructors	Instructors will also have to pay a small amount in order to provide all the features provided by elaborated feedback generating system to their assessment. Only a limited number of features will be free.
Educational institutes	Educational institutes will have to purchase a package from the system in order to provide special group assessment facilities.

Table D.2: Purchasing (Self composed)

1.2. Regulatory

1.1.3. Voluntary (Standardizing)

Stakeholder:	Viewpoint:
Universities	University academic staff working towards to improve the quality of education provided via e-learning systems.

Table D.3: Voluntary stakeholders (Self composed)

1.1.4. Enforcing

Stakeholder:	Viewpoint:
Government	Approve standards, policies within the county.
Educational Ministry	Make standards, policies.

Table D.4: Enforcing stakeholders (Self composed)

1.3. Implementability

1.3.1. Software Opinion

Stakeholder:	Viewpoint:
Developer Implementation	Developer has his own opinion towards implementing the system. He makes the system considering the expertise, knowledge and his own opinion.
Developer Maintenance	Maintenance developer has his opinion towards how the system should change from the lessons learned while maintaining the system. Easily recover the system on a system failure.

Table D.5: Software Opinion Stakeholders (Self composed)

Appendix E: Online survey questionnaire targeting e-learning students

Age *

- ○ Below 18 years
- ○ 18 - 30 years
- ○ 31 - 50 years
- ○ Above 50 years

Gender *

- ○ Male
- ○ Female

What is the maximum educational qualification that you possess? *

- ○ O/L or A/L
- ○ Undergraduate
- ○ Graduated
- ○ Postgraduate

How often do you use e-learning systems/online courses? *

- ○ At least once in every 3 days
- ○ At least once a week
- ○ At least once a month
- ○ Rarely

What device would you use to follow online courses? *

- ○ Smart phone
- ○ Tablet
- ○ PC or Laptop

How would you prefer to use online courses? *

- ○ Web browser
- ○ Installing as an application

Why do you use e-learning systems/online courses? *

- ☐ My university/educational institute/office uses e-learning systems to exams/assessments
- ☐ To support your studies
- ☐ To learn something completely new
- ☐ To obtain a degree/diploma/certificate course

Are you doing the questionnaire/assessment provided at the end of the course? *

- ○ Yes
- ○ No
- ○ Sometimes
- ○ I have to do it because it is mandatory

Are you satisfied with the feedback you received after completing the assessment? Please rate the feedback provided with the following (1- low, 5- good). *

Feedback is what you get after completing the assessment including grading, marks, etc.

	1	2	3	4	5
Feedback is matched with your knowledge	○	○	○	○	○
Feedback is personalized according to skills	○	○	○	○	○
Feedback is personalized according personality	○	○	○	○	○
Feedback is personalized according to environment	○	○	○	○	○
Guide on next steps to improve	○	○	○	○	○
Motivate to act on their assessment	○	○	○	○	○
Feedback justifies how the mark/grade is derived	○	○	○	○	○
It identifies and reward specific qualities in student work	○	○	○	○	○

Feedback includes recommended learning material to read *

- ○ Yes

- No

Are you satisfied with the learning material recommended after completing the assessment? Please rate the learning material provided with the following (1- low, 5- good). *

	1	2	3	4	5
The learning material recommended via feedback are matched with knowledge					
The learning material recommended via feedback are matched with skills					
The learning material recommended via feedback are matched with personality					
The learning material recommended via feedback are matched with environment					
Guide on next steps to improve					
Motivate to continue the course					

What is the best thing about e-learning systems that you follow, considering the assessment and feedback provided? *

What is the worst thing about e-learning systems that you follow, considering the assessments and feedback provided? *

Appendix F: Interview Questions for E-Learning Instructors

1. How old are you?
2. What is your area of teaching?
3. How often do you use e-learning systems in teaching activities?
4. Do you assess students using e-learning systems?
5. How do you provide feedback to the students when you are using an online assessment system?
6. Are you satisfied with the feedback given via e-learning systems?
7. Is the feedback customized or is it general?
8. What do you want to include in a feedback provided to a student?
9. Do you think that a personalized feedback will have a major impact on a student than a general feedback?
10. What are the best features that you have seen in online assessment systems?
11. What are the worst features that you have seen in online assessment systems?
12. What difficulties have you faced when using an e-learning system?

Appendix G: Interview Questions for E-Learning Expertise

1. For how long that you have work with e-learning systems?
2. What are the expected features of an online assessment system?
3. What are the features that should be included in a feedback provided at the end of an assessment?
4. What are the expectations of a feedback provided via an online assessment?
5. What are the best features that you have discovered in online assessment systems?
6. What are the worst features that you have discovered in online assessment systems?
7. What are the blockers in current e-learning assessment systems?
8. What are the characteristics that should be considered when customizing feedback?
9. Do you have any more features that you think which should be included in an online assessment system which generates personalized feedback?

Appendix H: Use Case Description

Use case number:	UC3	
Use case name:	View LMR	
Priority:	High	
Actor:	Student	
Summary:	The user views the LMR when he is presented with the feedback.	
Preconditions:	The user should be logged in to the system. User view the feedback.	
Extended use cases:	None	
Included use cases:	None	
Triggering event:	The user selects Learning material to view	
Main flow of events:	**Actor**	**System**
	1. Select learning material to view 3. View Feedback	2. Opens the browser and display the learning material
Alternative flow:	None	
Exceptional flow:	1. During the execution of the use case Internet connection interrupts or fails. • Use case ends in failure. 2. In step 2, failed to open the browser • An error message is thrown, and the use case ends in failure.	
Post conditions	The user is presented with LMR.	

Table H.1: Use case description for view LMR (Self composed)

Use case number:	UC4
Use case name:	Do assessment
Priority:	High
Actor:	Student
Summary:	User does the assessment.
Preconditions:	The user should be logged in to the system. The user should be enrolled in a course.

Extended use cases:	View feedback	
Included use cases:	None	
Triggering event:	The user selects take quiz.	
Main flow of events:	**Actor**	**System**
	1. Select the assessment 4. Answer questions 5. Submit answers	2. Load question from the database 3. Display question
Alternative flow 1:	5. Time exceeds before completing the assessment	6. Submits answers
Exceptional flow:	1. During the execution of the use case Internet connection interrupts or fails. • Use case ends in failure. 2. In step 2, failed to load questions from the database • An error message is thrown, and the use case ends in failure.	
Post conditions	The user is presented with view feedback option.	

Table H.2: Use case description for do assessment (Self composed)

Use case number:	UC5	
Use case name:	Login	
Priority:	Medium	
Actor:	Student, Tutor, Admin	
Summary:	User logs in to the system by entering credentials.	
Pre-conditions:	User should be in the login page.	
Extended use cases:	None	
Included use cases:	None	
Triggering event:	User selects to logging to the system.	
Main flow of events:	**Actor**	**System**
	1. Enter user name. 2. Enter password.	3. Validate credentials. 4. Logs in the user to the system. 5. Direct to post login page.

Alternative flow 1:	**Actor**	**System**
		4. Prompts invalid user name or password.
	5. Go to step 1.	
Exceptional flow:	1. In step 3, system finds that the given username doesn't exist. • An error message is thrown, and the use case ends in failure. 2. In step 3, the system finds that the given password doesn't match • An error message is thrown, and the use case ends in failure. 3. During the execution of the use case Internet connection interrupts or fails. • Use case ends in failure.	
Post conditions	If the user is a 1. Student: The system will display the enrolled courses 2. Tutor: The system will direct the user to the administrator panel	

Table H.3: Use case description for login (Self composed)

Use case number:	UC6	
Use case name:	Do LSM identification quiz	
Priority:	Medium	
Actor:	Student	
Summary:	User does the LSM identification quiz	
Pre-conditions:	Use should be logged in to the system.	
Extended use cases:	Do assessment	
Included use cases:	None	
Triggering event:	User selects to take the LSM identification quiz.	
Main flow of events:	**Actor**	**System**
	1. Select do quiz 4. Answer questions 5. Submit answers	2. Load question from the database 3. Display question
Alternative flow:	None	
Exceptional flow:	1. During the execution of the use case Internet connection interrupts or fails. • Use case ends in failure.	

	2. In step 2, failed to load questions from the database • An error message is thrown, and the use case ends in failure.
Post conditions	User is presented with the quiz page.

Table H.4: Use case description for do LSM identification quiz (Self composed)

Use case number:	UC7	
Use case name:	Enroll course	
Priority:	Medium	
Actor:	Admin	
Summary:	Admin enroll user to a course in order to do assessments.	
Pre-conditions:	Admin should be logged in to the system.	
Extended use cases:	Do LSM identification quiz	
Included use cases:	None	
Triggering event:	User selects to enroll to a course.	
Main flow of events:	**Actor**	**System**
	1. Select the course to enroll 2. Clicks on enroll to the course	3. Enroll user to the course 4. Save data in the database
Alternative flow:	None	
Exceptional flow:	1. During the execution of the use case Internet connection interrupts or fails. • Use case ends in failure. 2. In step 4, failed to save data into the database • An error message is thrown, and the use case ends in failure.	
Post conditions	User is presented with the courses page.	

Table H.5: Use case description for enroll course (Self composed)

Use case number:	UC8
Use case name:	Register users
Priority:	Medium
Actor:	Admin
Summary:	Admin registers users to the system by providing a unique user name, temporary password and the user type.

Pre-conditions:	Admin should be logged in to the system. Admin should be in the add user page.	
Extended use cases:	Login	
Included use cases:	None	
Triggering event:	Admin selects to add new users.	
Main flow of events:	**Actor**	**System**
	1. Select add new user 2. Enter user details	3. Validate credentials. 4. Adds user to the system. 5. Save data in database 6. Direct to page which displays the users.
Alternative flow 1:	**Actor**	**System**
		4. Prompts user already exists.
	5. Go to step 2.	
Exceptional flow:	1. In step 5, failed to save data in the database. • An error message is thrown, and the use case ends in failure. 2. During the execution of the use case Internet connection interrupts or fails. • Use case ends in failure.	
Post conditions	Admin is presented with the page which displays users of the system.	

Table H.6: Use case description for sign up (Self composed)

Use case number:	UC9
Use case name:	Create course
Priority:	Medium
Actor:	Tutor, Admin
Summary:	User creates a course by entering course details.
Pre-conditions:	Tutor should be logged in to the system. Tutor should be in the create course page
Extended use cases:	Add assessment, Enroll course
Included use cases:	None
Triggering event:	Tutor selects to add new course.

Main flow of events:	**Actor**	**System**
	1. Select add new course 2. Enter course details	3. Validate details. 4. Adds course to the system. 5. Save data in database 6. Direct to page which displays the courses.
Alternative flow 1:	5. Go to step 2	4. Validation fails
Exceptional flow:	1. In step 5, failed to save data in the database. • An error message is thrown, and the use case ends in failure. 2. During the execution of the use case Internet connection interrupts or fails. • Use case ends in failure.	
Post conditions	Tutor is presented with the page which displays courses.	

Table H.7: Use case description for create course (Self composed)

Use case number:	UC10	
Use case name:	Add assessment	
Priority:	Medium	
Actor:	Tutor, Admin	
Summary:	User adds an assessment by entering questions.	
Pre-conditions:	Tutor should be logged in to the system. Tutor should be in the add quiz page.	
Extended use cases:	Add question	
Included use cases:	None	
Triggering event:	Tutor selects to add new quiz.	
Main flow of events:	**Actor**	**System**
	Select add new assessment Select assessment type Add questions	Validate details. Adds assessment to the system. Save data in database

		Direct to page which displays the assessments.
Alternative flow 1:	6. Go to step 3	5. Validation fails
Exceptional flow:	1. In step 6, failed to save data in the database. • An error message is thrown, and the use case ends in failure. 2. During the execution of the use case Internet connection interrupts or fails. • Use case ends in failure.	
Post conditions	Tutor is presented with the page which displays quizzes.	

Table H.8: Use case description for add assessment (Self composed)

Appendix I: ERD for Browser History Database

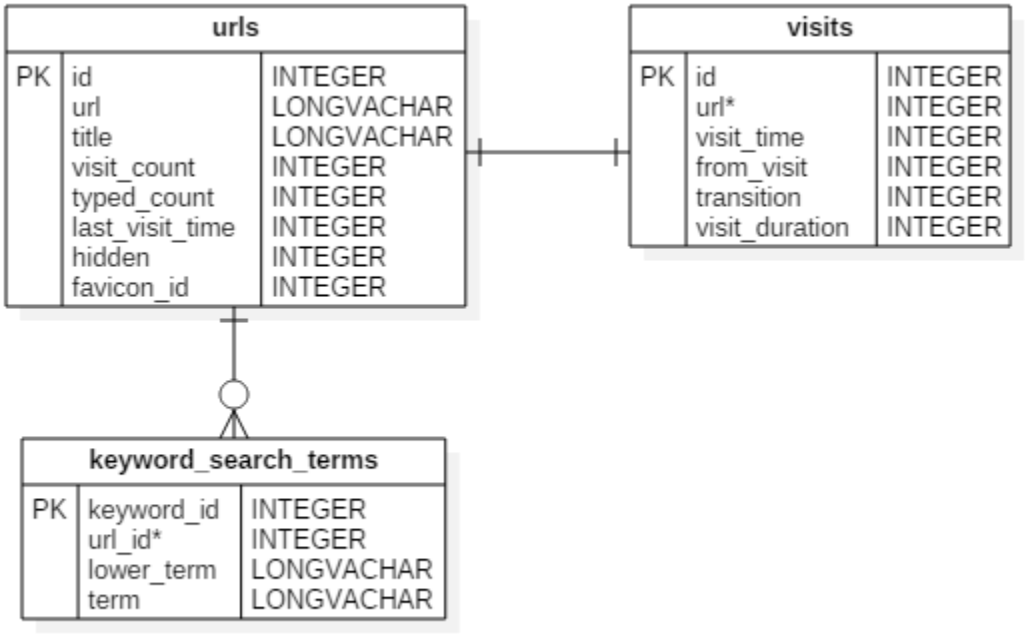


Figure I.1: ERD for browser history database (Self composed)

Appendix J: Class diagram

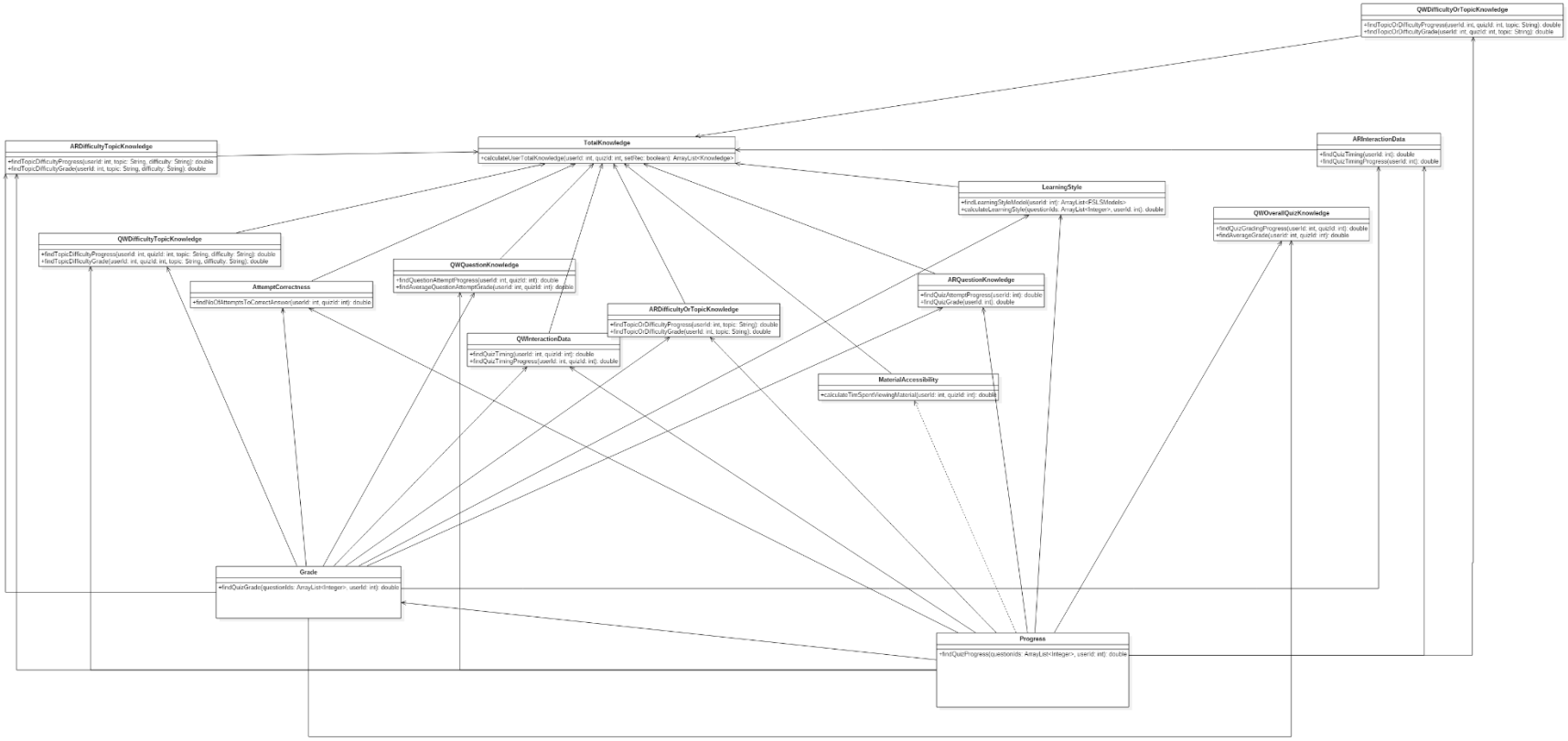


Figure J.1: Class diagram (Self composed)

Appendix K: Technology Selection

Section 1 - Critical Evaluation of Online Assessment Technologies

Technology	Moodle	
Description	Moodle refers to Modular Object-Oriented Dynamic Learning Environment which is an open source learning platform which is designed to provide administrators, educators, and learners with a robust, secured and integrated system to create personalized learning environments. This is written in PHP and distributed under the GNU. Programmers can extend features using self-developed PHP plugins and create custom web apps.	
Advantages		**Disadvantages**
• 100% Open Source. • Layout and organization structure of Moodle is easier to navigate and utilize because of Moodle's structure. • Have better administrative features • Allows for many different types of content formats to be uploaded and available for users.		• Difficult to use by people with poor technical skills. • Not yet enterprise ready. • Not able to support "mission critical" programs.
Impact	• No extra cost and developer's task becomes easy. • Better administrative features provide easy managing the assessments.	

Table K.1: Moodle (Self composed)

Technology	Joomla LMS	
Description	Joomla LMS is a learning management system based on Joomla.	
Advantages		**Disadvantages**
• Secured • Architecture is convenient in building e-learning systems.		• Partially open source • Pricing depends on the number of users, which means that Administrators, teachers, regular registered users are not counted only the number of students are countered.
Impact	• When the number of users' increase, the pricing increases.	

Table K.2: Joomla LMS (Self composed)

Technology	Latitude Learning	
Description	Latitude's Learning Center is built to manage the extended enterprise training programs.	
Advantages		**Disadvantages**
• Clear LMS service and product descriptions.		• Latitude is a bit complex and has a learning curve.
Impact	• The developer has to spend much time on learning.	

Table K.3: Latitude Learning (Self composed)

Section 2 - Critical Evaluation of Programming Language to Write the Main Component

Language	Java	
Description	An object oriented programming language and a platform released by Sun Microsystems in 1995.	
Advantages		**Disadvantages**
• Author familiarity with the programming language is high. • Good community support to develop machine learning projects. • A large number of widely used open source libraries can be found to implement machine learning algorithms and to train data sets. • High accuracy with the supporting libraries.		• No language specific disadvantages found in the discussed topic area.
Impact	• No extra cost and developer's task becomes easy since the language is familiar.	

Table K.4: Critical evaluation of Java (Self composed)

Language	C#	
Description	C# is a sophisticated and type-safe object oriented language that enables developers to build a variety of secure and robust applications that run on the .NET Framework	
Advantages		**Disadvantages**
• Average community support to develop machine learning projects.		• Author familiarity with the programming language is low. • Less number of libraries and some of them are not free.

Impact	• Since the author's familiarity is low, the author has to put some additional effort while implementation. • Since some libraries are not free it is advisable to go for a high cost solution if there are less cost libraries are available with better features.

Table K.5: Critical evaluation of C# (Self composed)

Language	Python
Description	Python is an interpreted, object-oriented, high-level programming language with dynamic semantics.
Advantages	**Disadvantages**
• Good community support to develop machine learning projects. • Have to code from the basic level.	• The author has to learn the language.
Impact	• Since the author has no experience in the language, author has to put more effort to learn the language. • Coding may take more time since the implementation should be start from the basic level.

Table K.6: Critical evaluation of Python (Self composed)

Language	Scala
Description	Scala is an acronym for "Scalable Language" and Scala is a pure-bred object-oriented language.
Advantages	**Disadvantages**
• Good community support to develop machine learning projects. • Have to code from the basic level.	• The author has to learn the language.
Impact	• Since the author has no experience in the language, author has to put more effort to learn the language. • Coding may take more time since the implementation should be start from the basic level.

Table K.7: Critical evaluation of Scala (Self composed)

Section 3 - Critical Evaluation of Machine Learning Libraries

Library	Weka

Description	Waikato Environment for Knowledge Analysis is a collection of machine learning algorithms written in Java for data mining tasks. These algorithms can be applied directly to a dataset or called from Java code. Weka comprises of tools for data pre-processing, classification, regression, clustering, association rules, and visualization.
Advantages	**Disadvantages**
• Have a graphical user interface which allows to run experiments on small datasets and help beginners. • Includes a large set of well-optimized machine learning and data analysis algorithms as well as various supporting routines that handle formatting, data transformation, and related tasks. • High accuracy • As Weka is implemented in Java, it is platform independent & portable. • Supports model based collaborative filtering, content based filtering and k-Means clustering	• Main package is not well optimized for memory intensive tasks on large datasets.
Impact	• GUI helps beginners to learn quickly. • Can expect a high accuracy from the proposed solution by using Weka algorithms. • A Large set of different data mining algorithms provides the chance to apply the correct algorithm without any difficulty.

Table K.8: Critical evaluation of Weka (Self composed)

Library	Apache Mahout
Description	Mahout is to create scalable machine learning applications. The 3 key components of Mahout are an environment for building scalable algorithms, many new Scala + Spark and H2O (Apache Flink in progress) algorithms, and Mahout's mature Hadoop MapReduce algorithms.
Advantages	**Disadvantages**
• Supports collaborative filtering • Supports k-Means clustering • Designed specifically for big data and capable of handling large volumes of data.	• Command line interface which takes time to learn and setup • Documentation is spotty and getting it to work is difficult. • Less algorithms compared to Weka • Less accuracy compared to Weka

Impact	• Not much user friendliness to beginners make the developer task difficult.

Table K.9: Critical evaluation of Apache Mahout (Self composed)

Library	Spark	
Description	Apache Spark is a powerful open source processing engine built around speed, ease of use, and sophisticated analytics. It was originally developed at UC Berkeley in 2009.	
Advantages		**Disadvantages**
• Faster than Hadoop, • Includes MLLib, which contains a good selection of machine learning algorithms, including classification, clustering and recommendation generation. • Spark comes with GraphX, a distributed graph system.		• Spark is still working on bugs as it matures. • Consumes a lot of memory, and there are issues in memory consumption while garbage collection is not handled in a user friendly manner.
Impact	• Can't guarantee about the accuracy since it's still working on bugs.	

Table K.10: Critical evaluation of Apache Spark (Self composed)

Appendix L: Test cases

Test case	Scenarios	Input data	Expected result	Actual result	Status	Success rate
TC1	Create user profile	With valid user name and password with other details.	User profile created successfully.	User profile created successfully.	Pass	100%
TC2	Create user profile	With invalid user name and password with other details.	Error message displayed about the invalid user name or the password.	Error message displayed about the invalid user name or the password.	Pass	100%
TC3	Create user profile	With existing user name and password with other details.	Error message displayed about the user name existence.	Error message displayed about the user name existence.	Pass	100%
TC4	Login to the system	Correct user name and password.	Successfully login.	Successfully login.	Pass	100%
TC5	Login to the system	Wrong user name and correct password.	Login fails and an error message should be displayed.	Login fails and an error message should be displayed.	Pass	100%
TC6	Login to the system	Correct user name and wrong password.	Login fails and an error message should be displayed.	Login fails and an error message should be displayed.	Pass	100%
TC7	Create course	Valid course name data.	Course created successfully.	Course created successfully.	Pass	100%
TC8	Create course	Empty course data.	Error in creating the course.	Error in creating the course.	Pass	100%
TC9	Create course	Invalid course name.	Error in creating the course.	Error in creating the course.	Pass	100%

TC10	Add assessments	Valid assessment data.	Assessment created successfully.	Assessment created successfully.	Pass	100%
TC11	Add assessments	Empty assessment data.	Error in creating the assessment.	Error in creating the assessment.	Pass	100%
TC12	Add assessments	Invalid assessment data.	Error in creating the assessment.	Error in creating the assessment.	Pass	100%
TC13	Add questions to an assessment	Valid question data.	Question saved successfully.	Question saved successfully.	Pass	100%
TC14	Add questions to an assessment	Invalid question data.	Error in saving the question.	Error in saving the question.	Pass	100%
TC15	Add questions to an assessment	Empty question data.	Error in saving the question.	Error in saving the question.	Pass	100%
TC16	Enroll students to courses	Select the student with the course.	Student successfully enrolled to the course.	Student successfully enrolled to the course.	Pass	100%
TC17	Generate feedback with learning material recommendations	Assessment answers.	Generate feedback with RLM successfully.	Generate feedback with RLM successfully.	Pass	100%
TC18	View RLM	Clicks on a link of LM.	Display LM on the browser.	Display LM on the browser.	Pass	100%
TC19	Save generated feedback	Clicks on the review button of a previous quiz attempt.	Display saved feedback.	Display saved feedback.	Pass	100%

TC20	View feedback	Submits assessment answers.	Display feedback with RLM.	Display feedback with RLM.	Pass	100%

Table L.1: Test cases (Self composed)