Performance Analysis of HSC ICT e-Learning System Based on Revised Bloom's Taxonomy

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Declaration of Authorship

This is hereby declared that the report titled "Performance Analysis of HSC ICT e-Learning System based on Revised Bloom's Taxonomy" is the outcome of the project work carried out by me under the supervision of Prof. Dr. Abu Sayed Md. Latiful Hoque, in the Department of Computer Science and Engineering, Bangladesh University of Engineering and Technology, Dhaka. It is also declared that this report or any part of it has not been submitted elsewhere for the award of any degree or diploma.

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The project report titled "**Performance Analysis of HSC ICT e-Learning System based on Revised Bloom's Taxonomy**", submitted by Md. Farhad Hoshen Bakaul, Roll No. 1015052075, Session October 2015, to the Department of Computer Science and Engineering, Bangladesh University of Engineering and Technology, has been accepted as satisfactory in partial fulfillment of the requirements for the degree of Master of Engineering in Computer Science and Engineering and approved as to its style and contents. Examination held on April 26, 2022.

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Abstract

The ICT course at Higher Secondary Level of Bangladesh has six chapters namely Information and Communication Technology: World and Bangladesh Perspective, Communication System and Networking, Number System and Digital Devices, Introduction to Web Design and HTML, Programming Language, and Database Management System. Introduction of programming at this level has created new challenges for computer education due to the crisis of experienced teaching staffs, insufficient laboratory facilities, Internet accessibility and appropriate course materials etc. HSC ICT Online is a web based interactive and adaptive e-learning system for effective learning and teaching of ICT course which aims to overcome the limitations in a constrained resources environment in a developing country like Bangladesh.

In this project, we have performed systematic analysis to measure the effectiveness of the HSC ICT e-Learning system in compared to traditional learning system. Bloom's Taxonomy and the Revised Bloom's Taxonomy has long been a tool used by educators, instructional designers, and others developing innovative processes. They use it to reach all cognitive levels in the traditional classroom by creating and orchestrating goals, lessons, and assessments. We have applied Revised Bloom's Taxonomy with the use of fuzzy weights in order to analyze the contents of the HSC ICT e-Learning system and compared with the HSC ICT textbook. We also tried to measure the effectiveness and usability of the system along with other evaluation matrices based on user feedback as it was used by the students and teachers of different colleges in Higher Secondary Level. The analytical result has been found to be very much satisfactory.

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Abbreviations

HSC	**Higher Secondary School**
ICT	**Information and Communication Technology**
RBT	**Revised Bloom's Taxonomy**
PBeL	**Problem Based eLearning System**
EBL	**Example Based Learning**
NCTB	**National Curriculum and Textbook Board**
HTML	**Hypertext Markup Language**
SQL	**Structured Query Language**
eLS	**e-Learning System**

CHAPTER 1

INTRODUCTION

1.1 ICT Course at HSC Level in Bangladesh

This is the age of information technology. In order to harness the power of information technology and adapt to today's world by building human technological capabilities, the government of Bangladesh has taken certain steps to integrate ICT into the education system. The implementation of the Information and Communication Technology curriculum at the Secondary and Higher Secondary level is one of the efforts to improve the quality of education. The National Curriculum and Textbook Board (NCTB) of Bangladesh have introduced information and communications technology (ICT) as a compulsory subject in 2009 for higher secondary students. An ICT course is a practical subject that requires specific practice to facilitate the learner's understanding. ICT course has two types of contents: textual and programming. The programming parts are Hyper Text Mark-up Language, C programming and SQL relational database. The introduction of programming at this level has created few new challenges for computer education in a developing country like Bangladesh and several obstacles have been identified that impede the effective integration of ICT. These are: the crisis of experienced teaching staffs, insufficient laboratory facilities, Internet accessibility and appropriate course materials [1][2]. Failure to properly study this subject has a detrimental effect on Computer Science education at higher levels. In this case, a media/ learning aid tool that can provide learning materials and useful tips or feedback can help students learn more effectively and reduce the shortcomings of the traditional ICT learning.

1.2 HSCICT e-Learning System

HSC ICT Online is an e-learning system based on the PBeL model [3] which helps students of HSC level in Bangladesh to learn programming languages like C, HTML, and SQL query language according to the textbook of the National Curriculum and Textbook Board [4]. It is a web-based e-Learning system (eLS) for effective learning and teaching of the ICT course. The main features of the system are interactive, self-learning and self-evaluation capabilities and student engagement based on Problem-Based e-Learning (PBeL) model. The programming interfaces e.g., HTML, C and SQL have been integrated with the textual contents of the book. So, the students can learn the programming contents and gain experience by running programs without the installation of complex programming environment. Students' activities in the system are saved to his/her account and can be retrieved for future reference. A teacher can see the submissions of the students under him for guidance and evaluation. The system has been used by the students and teachers of different colleges in higher secondary level.

1.3 Revised Bloom's Taxonomy

Taxonomies in education are the classification programs based on organizational structure. It is a collection of carefully defined words, organized from simple to complex and from concrete to unambiguous, providing a framework for categories in which one can classify educational goals. [5].

A popular learning theory, Bloom's taxonomy is a set of hierarchical models used to divide learning objectives into complex and elaborate levels. The framework described by Bloom et al comprises six major phases [6] and was lately revised (RBT) by Krathwohl et al [7] to expand on the original concept during language review and classification of Cognitive Process Dimension. The original taxonomy was organized into three domains: Cognitive, Affective, and Psychomotor. Educators have primarily focused on the Cognitive model, which includes six different classification levels: Knowledge, Comprehension, Application, Analysis, Synthesis, and Evaluation. The team sought to design a logical framework for learning and learning goals that would help researchers and teachers understand the important ways in which people acquire and develop new knowledge, skills, and understanding. In the revised version, three categories were renamed and all categories were presented as verbs instead of nouns. Knowledge was changed to Remember, Comprehension became Understand, and Synthesis was renamed to Create. In addition, ‘Create’ became the highest level in the classification system, switching places with Evaluating. The revised version is now Remember, Understand, Apply, Analyze, Evaluate, and Create, in that order.

1.4 Background of the Project

Although digital or online education may not replace classroom learning, e-learning can enhance students' learning process as it offers many benefits to students. It has no time and space limits and allows for flexible and personal reading at the student's speed. However, the effectiveness of e-learning is still unknown as its effectiveness is influenced by many factors. Some factors create barriers for online learning, such as management issues, social media, academic skills, technical skills, student motivation, time and course support, technical issues, costs and access to the interne. Other factors may result in lower quality online learning, for example less efficient design and multimedia editing [2].

Despite the widespread use of e-learning systems, there is no consensus on the standard framework for e-learning system evaluation and the effectiveness of online learning / teaching performance is still difficult. However, the effectiveness of technology tools and resources is measured in a variety of educational ways based on learning objectives, design features of learning materials, assessment of learning outcomes, etc. Performance testing is another feature that represents the standard test method. efficiency, ease of use, convenience and ease of user-focused design for a variety of computer systems including e-learning systems. In recent years, there has been a growing interest in the content analysis in terms of their complexity. Bloom’s Taxonomy, a cognitive skills taxonomy is widely used in almost any known education field for course design and evaluation [8], structuring assessments [9] and comparing the cognitive difficulty level of computer science courses [10]. Revised Bloom’s Taxonomy is also used to assess coherence between curriculum, teaching, and assessment, to plan teaching and lesson activities, design assessment, and evaluate students' skills, knowledge and performance. Although researchers have used Bloom's taxonomy to evaluate students' reading in a general setting, they have not yet fully explored the e-learning system. This is probably due to the differences in both approaches. Students' physical distance, their lack of direct answers, and the lack of boundaries in the e-learning environment present challenges the assessment process of the learning process.

The purpose of the project is to explore the e-learning system of HSC ICT on the basis of Revised Bloom’s Taxonomy. Each e-learning component will be measured on the basis of the objectives contained in Bloom's taxonomy. Since the usefulness and usability of the system depends largely on the user's success in completing the relevant tasks, performance utilization plays an important role. We will also evaluate system performance based on teachers and students and ideas for their feedback using the Likert scale sometimes called the satisfaction scale, which goes from one extreme attitude to another. [11].

1.5 Objectives of the Project

Objectives of the project are to:

(i). Analyze and classify the contents of HSC ICT e-Learning System and HSC ICT textbook and compare them.

(ii). Applying Revised Bloom’s Taxonomy with Fuzzy Algorithm to evaluate the system and students’ performance in Programming Languages (C, HTML, SQL Query) on HSCICT e-Learning System.

(iii) System evaluation based on the user’s feedback system using Likert Scale for testing usability of the system.

1.6 Methodology

HSC ICT Online is a PBeL based learning system where each course has multiple chapters of contents of different cognitive levels of complexity in their curriculum following the guidelines of NCTB. In the beginning, the contents and learning activities of each module will be classified into six cognitive levels according to the complexity from basic to more complex as per RBT.

Secondly, we will compare and evaluate the system and the HSC ICT textbook, the concept of Revised Bloom Taxonomy will be used along with pre-specified fuzzy weights which will identify the knowledge level for learning C, HTML, SQL programming language. These weights are represented as trapezoidal membership functions with their boundary values. The reason why trapezoidal membership functions were chosen is that at each category of knowledge level, there is an interval where students' scores fully belong to the category.

Thirdly, system evaluation for usability testing will be performed based on user feedback to the system. In the end, the learning strategy and the outcome of the system will be analyzed for its enhanced adaptivity, effectiveness, and student engagement to the system.

1.7 Organization of the Project Report

The rest of the report is organized as follows:

In chapter 2, we discuss about some evaluation techniques used for performance analysis of e-learning systems.

In chapter 3, we present our HSC ICT e-Learning Systems architectural design and operational procedures.

In chapter 4, we discussed about Revised Bloom's Taxonomy and its application in evaluating e-learning systems and about performance analysis methodologies used for HSC ICT e-Learning System.

In chapter 5, we present the experimental results.

In chapter 6, we conclude our report with further discussion.

CHAPTER 2

RELATED WORKS

In this chapter, we will discuss about few existing tools and systems that can help students to learn the concepts of ICT Course according to the HSC ICT syllabus by NCTB. Then we will discuss about some of the used evaluation techniques for eLearning Systems evaluation. Lastly, we will explore the application of Revised Bloom's Taxonomy as eLearning System evaluation method.

2.1 e-Learning Systems for HSC ICT Course

Tariqul et al proposed a Web Based Collaborative Learning (WBCL) model called "ICT Course Helper (ICH)" to expand ICT-based student knowledge by discussing topics related to ICT courses in Bangladesh [12]. The methods they use are: Advanced Learning Materials (TEL), Questions and Answers (QA) Procedure and Group Discussions (GD). They found the success of their model in their analysis but the method of their analysis was not disclosed.

Mumtahina et al introduced the design and implementation of web-based education archive and collaborative self-assessment program to promote (teaching and learning) ICT education (both for teachers and students) of Bangladesh Secondary and Tertiary levels. The app should include content design, web portal development and Android mobile app development. The content would be mapped with a syllabus of the board and learning materials: educational resources (e.g., video lessons, books) would be provided to teachers to help them prepare for their lessons and for the student to be able to attend the questions [13]. But there is no proof of performance analysis of both systems available, and these were not available online.

ASML Hoque et al proposed a model Problem-based eLearning (PBeL) which describes the structure of the PBeL problems. In the system, the development of the problem-bank and learning and teaching is in both synchronous and asynchronous mode. They implemented the model for learning and teaching of HTML part of ICT course at Higher Secondary (HSC) level in Bangladesh and applied to the students of HSC level of different colleges. The result obtained was very much satisfactory and encourages for the application of the model for other programming languages [3][14]. The HSC ICT eLearning System was built based on their proposed model. In this project we are going to analyze the performance based on Revised Bloom's Taxonomy in collaboration with student feedback system.

2.2 Evaluation Techniques for E-Learning Systems

Despite the widespread use of e-learning systems, there is no consensus on devising a standard framework for evaluating system quality in this area.

B. B. Chua et al proposes the ISO 9126 Quality Model as a useful tool for evaluating such systems. They applied the model to the system in the context of an Information Technology subject in an undergraduate programme and the results of the evaluation of the system showed that the model was a good framework for assessing e-learning systems, but several possible refinements to the model was identified particularly with regards to the Usability characteristic in further study [15].

Roberts gained a good overview of Blackboard using surveys, focus groups and interviews, but the results are too general and do not provide detailed analysis of features such as usability [16].

S. Ozkan et al proposes a conceptual e-learning assessment model, HELAM (Hexagonal e-Learning Assessment Model), suggesting a multi-dimensional approach for LMS evaluation via six dimensions: (1) system quality, (2) service quality, (3) content quality, (4) learner perspective, (5) instructor attitudes, and (6) supportive issues. The proposed assessment model has been tested using a survey instrument based on HELAM for content validity, reliability, and criterion based predictive validity. Even though the statistical analyses and pertinent literature allowed the researchers to propose a comprehensive LMS evaluation model, it is important to note that this instrument focuses on assessing the effect of each HELAM dimension on overall e-learning perceived satisfaction only [18].

S. Silaban et al tried to evaluate the quality and the success of an eLearning system from the view of lecturers. This study was designed to reveal the quality and the success of ARO Gapopin eLearning system from point of view of the lecturer. A set of the survey questionnaire was designed to collect data needed for the system evaluation. However, this study just uncovers the perception of the faculties on the eLearning system. Data drawn from the result of descriptive statistics performed does not represent in-depth information about the system [19].

A. Al-Wani et al proposed a framework in the form of an instrument survey to evaluate the quality of digital content and its performance in an e-learning platform. Evaluation was made under seven primary criteria with multiple item questions to assess the performance of subject e-content in an e-learning environment. This instrument survey presented a basic structure for evaluating and assessing potential of an e-learning digital course [20].

Diana et al explained e-learning system performance evaluation based on faculties and students' perspective using the Web-Based Evaluation model of E-Learning system. They performed a case study by collecting data in several ways such as library, questionnaire, interviews, and survey through various sources, the students and lecturers also IT directorate at Binus University [21] [22].
N. Munkhtsetseg et al proposed a multicriteria evaluation methodology to evaluate open-source e-learning systems using Keeney & Raiffa's methodology [22].

Multicriteria decision making (MCDM) process involves the basic elements like criterion set, preference structure, alternative set, and performance values [23].

Nevertheless, these quantitative counts are not meaningful without details of the subject design, for example how the group area activities were incorporated into the learning environment.

2.3 Application of RBT for eLearning System Evaluation

Benjamin Bloom, an educational psychologist at the University of Chicago, headed a group of educational psychologists in 1956 to develop a multi-layered cognitive frame-work in learning domains in order to facilitate the instructors for evaluating their course material and testing outcomes [6]. This taxonomy has been divided learning into three behavioral domains namely cognitive, affective and psychomotor with the main focus on the cognitive domain because of its possible application in primary, secondary and tertiary education. Moreover, they determined the cognitive domain concerns of developing students' mental skills, the affective domain concerns of student attitudes, and psychomotor domain concerns of physical skills [6]. Each domain has a taxonomy associated with it, in which all domains together form the goals of the learning process. The cognitive domain encompasses a hierarchical series of intellectual skills involving the acquisition and use of knowledge that ranges from simple recall to the ability to judge and evaluate learned materials. Bloom identified six levels within the cognitive domain and provided carefully developed definitions for each of the six major categories in the cognitive domain as shown in Fig. 2.1: Knowledge, Comprehension, Application, Analysis, Synthesis, and Evaluation. Each category entails more intricate thinking than the one preceding it and integrates the previous levels of thought to advance to higher levels. The categories were hierarchically arranged and ordered from simple to complex and from concrete to abstract: lower-order skills that require less cognitive processing to higher-order skills that require deeper learning and a greater degree of cognitive processing [24]. Bloom believed that the mastery level in the first level is essential to achieve the second level and so on.

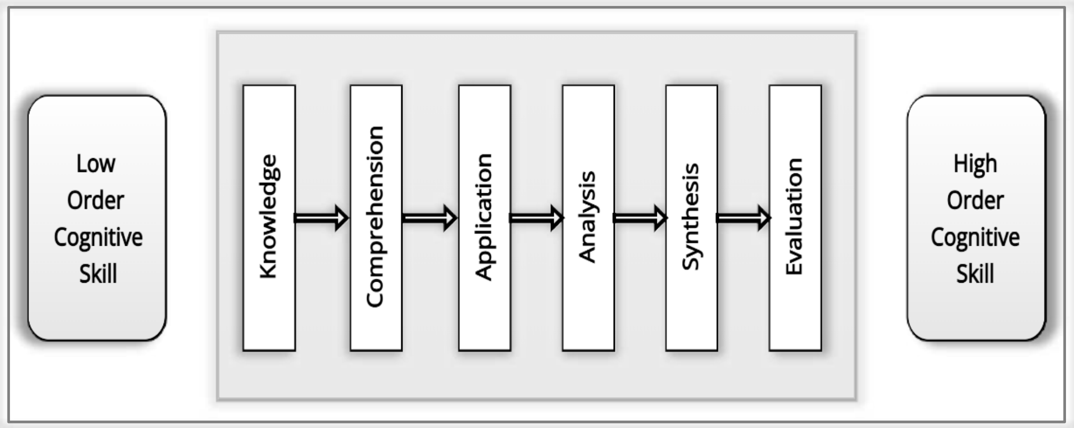


Fig. 2.1: Hierarchical levels in cognitive domain of bloom's taxonomy

It only has one dimension. Their definition [7] are shown in Table 2.1:

Table 2.1: Definitions of the levels associated with the original Bloom's Taxonomy

Level	Description
Knowledge	To remember or retrieve material that has been learnt before
Comprehension	To be able to grasp or construct meaning from material
Application	To be able to utilize learnt material, or to apply material in new and concrete settings
Analysis	TO be able to classify or distinguish the components Of material into its parts whereby its structure of organization to aid the understanding of the material
Synthesis	To be able to put components together for building up a coherent or unique new whole
Evaluation	To be able to judge, check, and even critique the material value for a given objective

The Bloom's Taxonomy was discovered to have several weaknesses. Anderson and Krathworthl reevaluated the original taxonomy and created a revised version of it. They changed the original taxonomy in three major ways, that is, terminology, structure, and emphasis. Out of the six levels, three were renamed and two of the levels were shuffled with their titles reflecting the actions or verbs instead of nouns. Similar to the old taxonomy, the revised one also represented a hierarchy with each level linked to the previous as a prerequisite.

The six levels are: remember, understand, apply, analyze, evaluate, and create as shown in Fig. 2.2, their definition is as shown in Table 2.2.

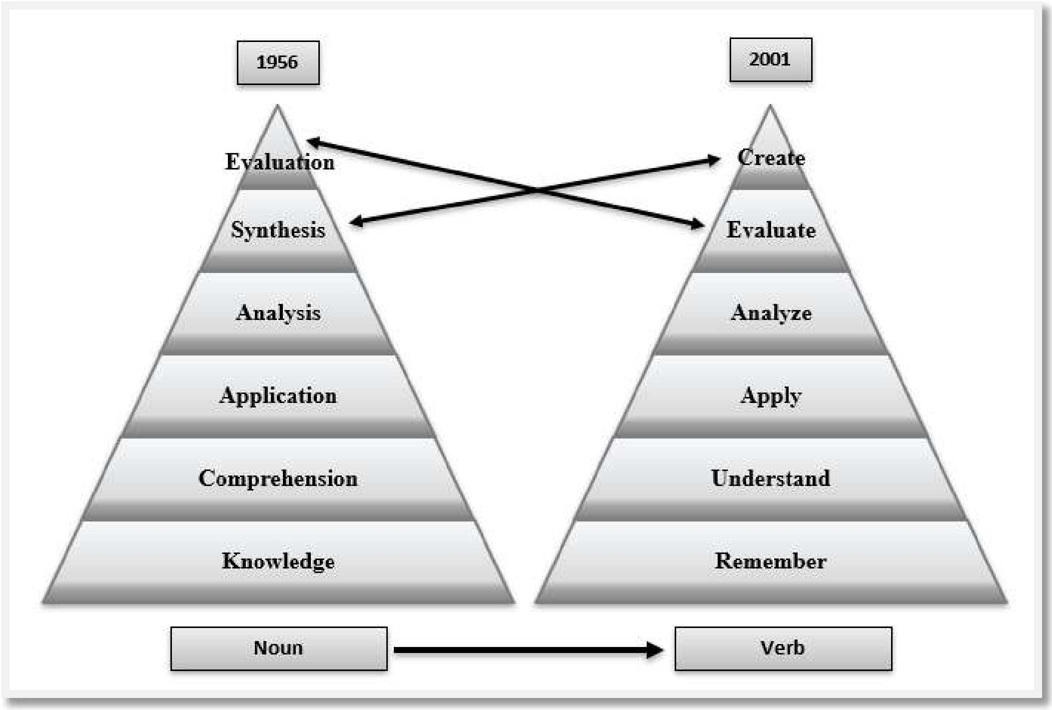


Fig. 2.2: Revised Bloom's Taxonomy

Table 2.2: Definitions of the levels of The Revised Bloom's Taxonomy

	Level	Description
1	Remember	To retrieve appropriate knowledge from long-term memory
2	Understand	To determine the meaning of instructional messages that come in the form of oral, written, and graphic communication
3	Apply	To perform or use a procedure in a given setting
4	Analyze	To break down the material into components and distinguish how the components are associated to one another and to a whole structure or purpose
5	Evaluate	To judge according to criteria and standards
6	Create	Putting elements together to form a novel, coherent whole or make an original product

The Revised Bloom's Taxonomy is more comprehensive to describe the levels of learning because the learning is classified into levels through two dimensions which are types of knowledge and cognitive process. The Knowledge Dimension classifies four types of knowledge that learners may be expected to acquire or construct— ranging from concrete to abstract (Table 2.3).

Table 2.3: The Knowledge Dimension – major types and subtypes

Concrete Knowledge	→	→	**Abstract Knowledge**
Factual	**Conceptual**	**Procedural**	**Metacognitive**
Knowledge of terminology	Knowledge of classifications and categories	Knowledge of subject-specific skills and algorithms	Strategic knowledge
Knowledge of specific details and elements	Knowledge of principles and generalizations	Knowledge of subject-specific techniques and methods	Knowledge about cognitive tasks, including appropriate contextual and conditional knowledge
	Knowledge of theories, models, and structures	Knowledge of criteria for determining when to use appropriate procedures	Self-knowledge

The Cognitive Process Dimension represents a continuum of increasing cognitive complexity—from lower order thinking skills to higher order thinking skills.

Although Bloom's taxonomy has been used by the researchers to evaluate students' learning in a traditional environment, they have not exhaustively investigated it in an e-learning setting. Bloom's taxonomy has long been a means applied by educators, instructional designers, and those developing innovative courses to create and align objectives, lessons, and assessments to achieve all cognitive levels of the traditional classroom.

Researchers have also used Bloom’s taxonomy as an assessment tool to evaluate student performance in traditional courses versus online simulations [2.17].

E. Thompson et al discussed each of the Bloom classification categories and provide a consistent interpretation with concrete exemplars that will allow computer science educators to utilize Bloom’s Taxonomy for programming assessment. Use of Bloom’s Taxonomy could help greatly to improve the quality of assessment in introductory programming courses [2.18].

Halawi et al presented an article to evaluate e-learning through WebCT on the basis of Bloom’s Taxonomy [2.19]. Each aspect of e-learning was measured on the basis of the objectives contained in Bloom’s taxonomy. To test the proposed hypothesis, they developed measurements for each variable with a combination of questionnaires for evaluating e-learning. The study had several limitations like the small sample size etc.

CHAPTER 3

HSC ICT E-LEARNING SYSTEM ARCHITECHTURE

In this chapter, we will describe an overview of the system architecture and design of HSC ICT e-Learning System and figure out the cognitive level complied by the architecture.

3.1 Analysis and Design of Content

The contents of ICT course at HSC level are divided into six modules as per the syllabus provided by NCTB which are as follows:

1) Information and communication technology: World and Bangladesh Perspective

2) Communication System and Networking

3) Number System and Digital Devices

4) Introduction to Web Design and HTML

5) Programming Language

6) Database Management System.

The content has been analyzed and decomposed in such a way that support the development of the system. Fig. 3.1 shows the detailed decomposition diagram of the system. In the decomposition diagram, it is shown that the first three modules, there are texts, graphics, MCQ and EBL (Example Base Learning). The last three modules additionally contain the PBeL as the component of the system. In these modules, there are programming parts and for learning and teaching of programming, PBeLs have been incorporated in the HSC ICT e-Learning System.

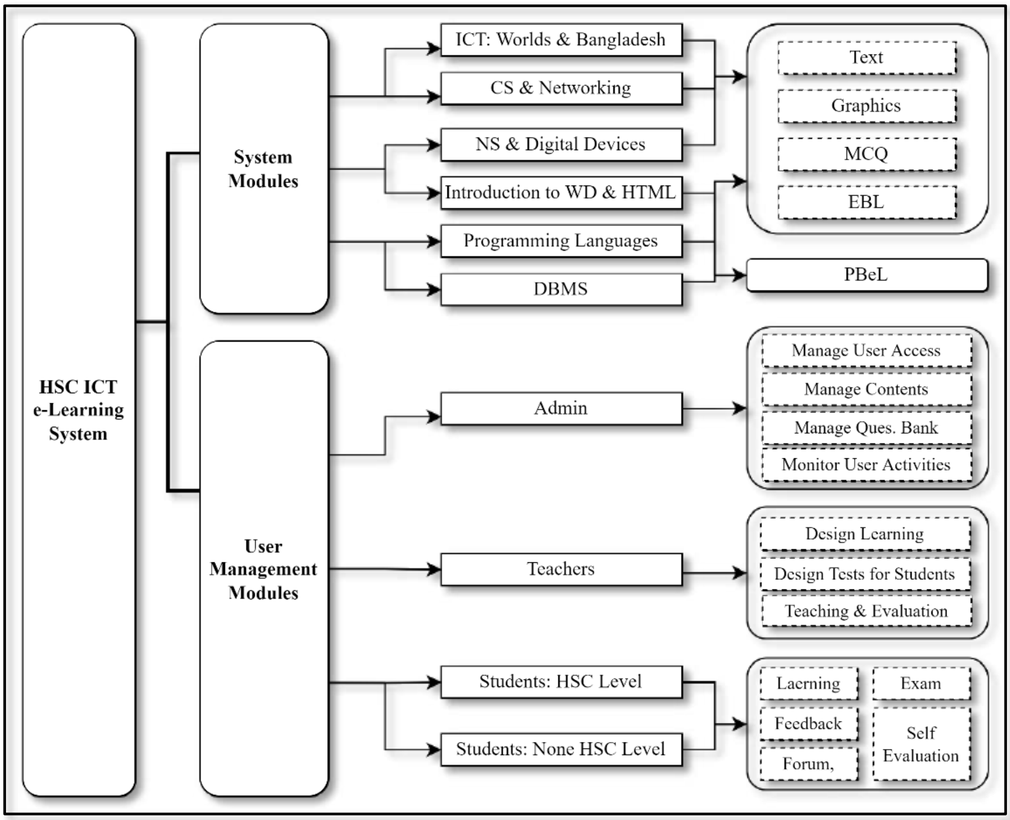


Fig. 3.1: Decomposition diagram of HSC ICT e-Learning System

3.2 System architecture

Fig. 3.2 shows the system architecture for HSC ICT Online eLearning System. There are six system modules for the management of interactive contents of six chapters, the problems and solutions management for blended synchronous learning covering the content and supporting lifelong learning. In a classroom in blended learning environment, always the progresses of the students are not the same. The progress of some students is very fast and the progress of some students are very slow. It is a challenging problem for the teaching and learning community to maintain the class room environment attractive, interactive and interesting for all levels of students as mentioned.

In this system, this challenge has been addressed by designing the problem bank in a hierarchical fashion as discussed in [3]. Each problem is a part of a big real-life problem. The higher the level of the problem, the difficulty of the problem is also higher. The lowest level problems are designed in such a way that it covers the entire content of the course.

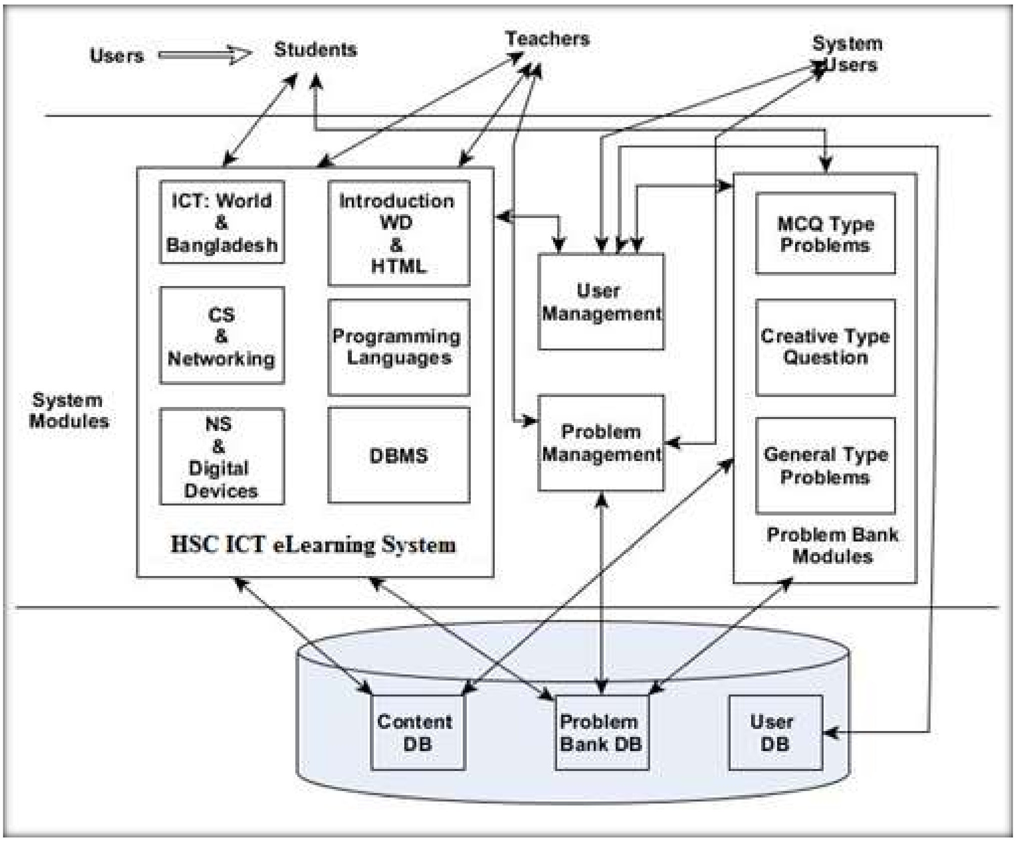


Fig. 3.2: System architecture for HSC ICT eLearning System

In the problem-bank module, there are three types of problems as suggested by NCTB and the course experts. These are the different types of Multiple-Choice Questions (MCQ), creative type questions and general type of questions. Problem-bank is used for multiple purposes e.g., learning and teaching in PBeL environment, self-learning, self-evaluation and the evaluation by the instructors. There are examinations held in different times for different levels of students in all colleges. The teachers can prepare the question-set of all types from the problem-bank or it can be prepared by running question-set preparation algorithm.

3.3 User Interaction with the System

The users of the system are students, teachers and system users. The system users interact with the user management module and the problem management module. They also be able to add surveys and conduct a survey. Student users has only one role of learning and self-evaluation. The teacher's roles are submission of questions as question setter, moderation of questions and preparation of question-set for different examinations and student evaluation.

3.3.1 Student's activities

The students interact with six modules of ICT course for learning purpose in different mode. The process of students learning activities is shown in Fig. 3.3.

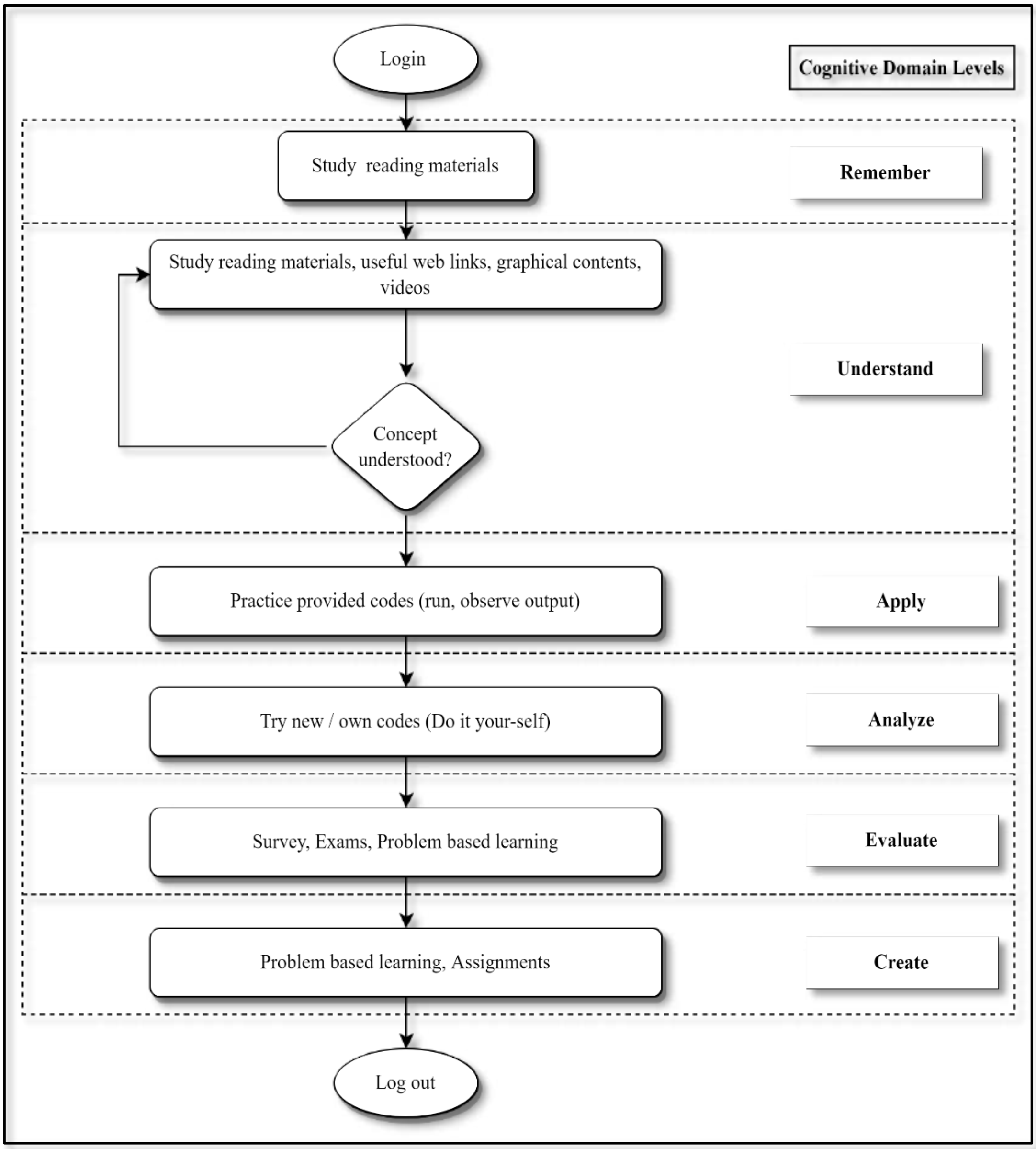


Fig. 3.3: Students learning activities based on cognitive domain levels.

We can see that, after register and login into the system, they can study through the chapters learning contents (texts, graphics etc.), can watch videos on provided topics. If any topic or word is hard to understand, he/she can explore that topic or word by clicking on that word, there they will get some extra information about that word/ topic in form of explanatory texts, useful web-links and videos which will help to enhance their knowledge and understanding. The process of exploring the additional explanatory contents is shown in Fig. 3.4.

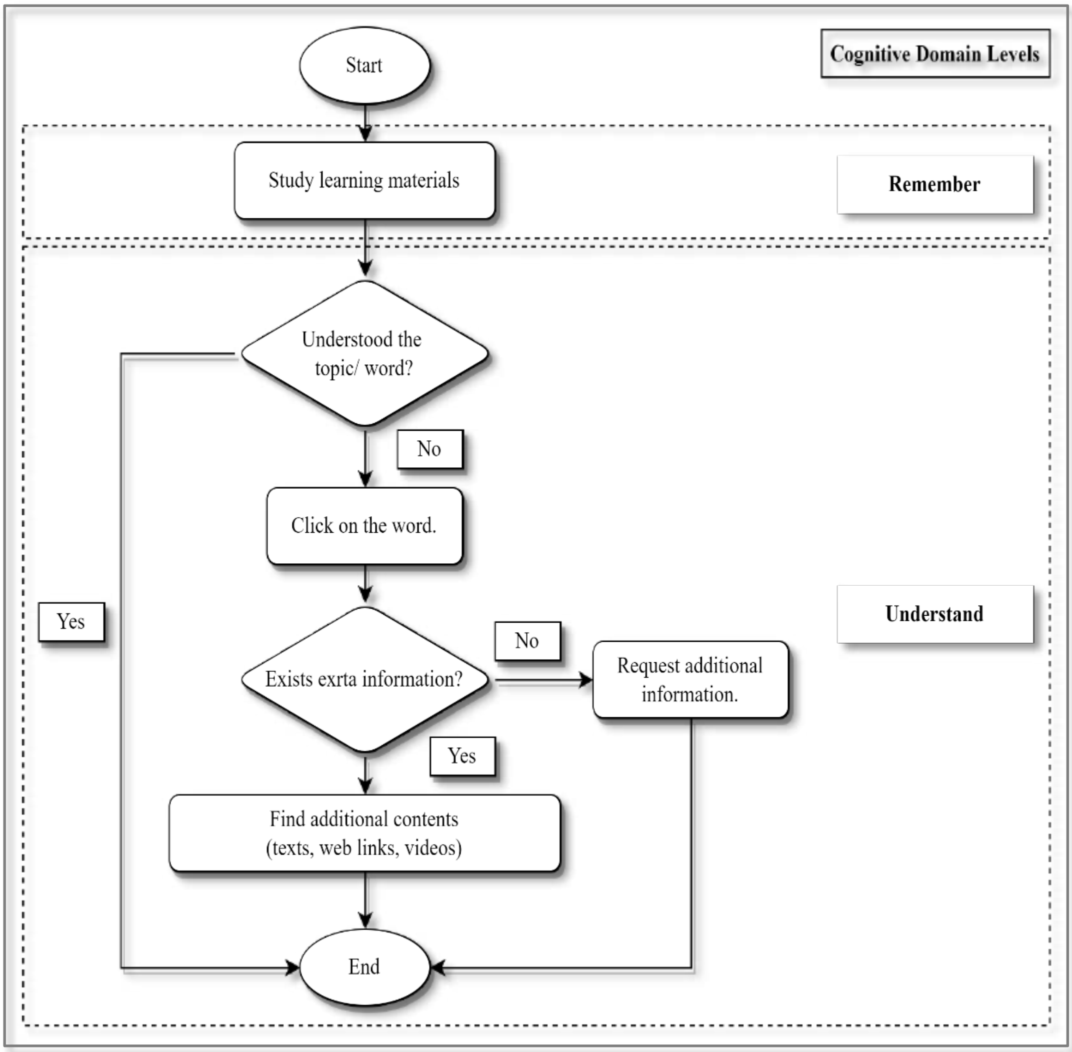


Fig. 3.4: Students process for exploring the additional explanatory contents.

The system has provided live coding facility for students where they can practice coding provided in the book and can also try their own code through live practicing option based on their learning of a topic or chapter. They are allowed to run, save and download their codes for later use as shown in Fig. 3.5.

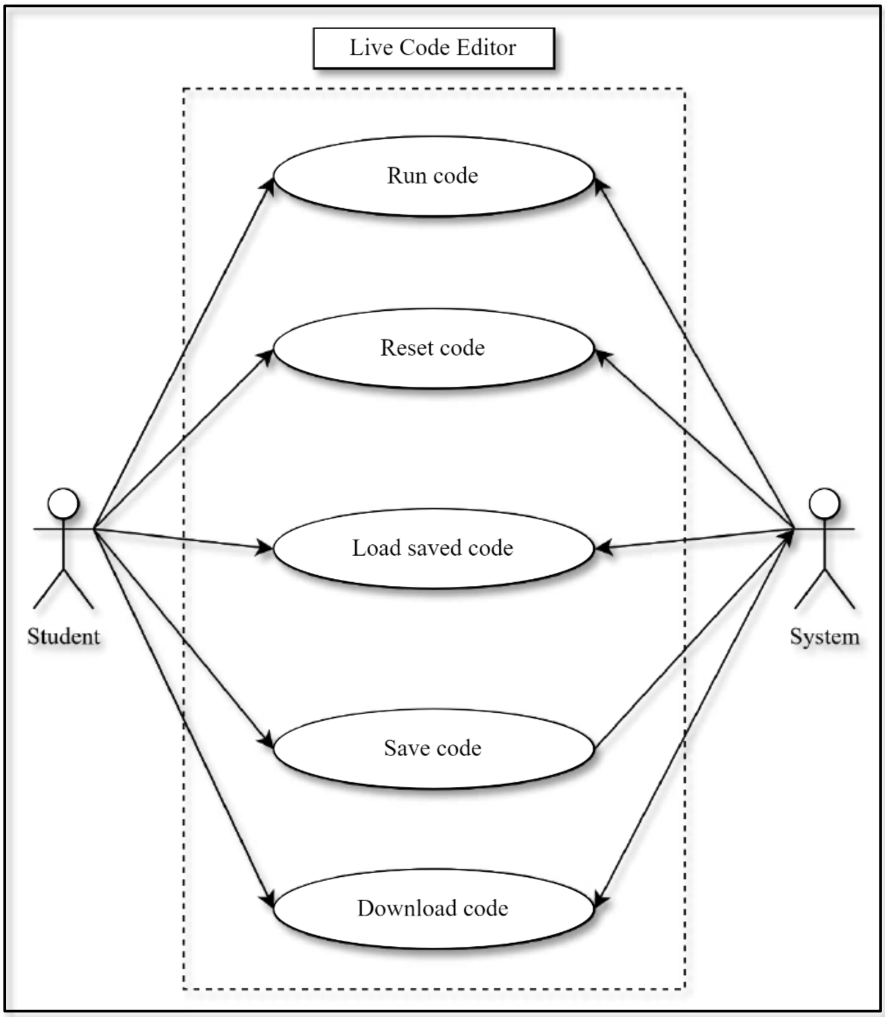


Fig. 3.5: Students live code practice activities.

The students also interact with problem-bank modules for appearing online examinations for self-evaluation or evaluation by the instructor.

They can find the information of his activity in the system and evaluation information through the ‘student dashboard’. Here they can find their activity timelines in the system, there answered MCQs and saved code of HTML, C programming and SQL quires as shown in Fig. 3.6.

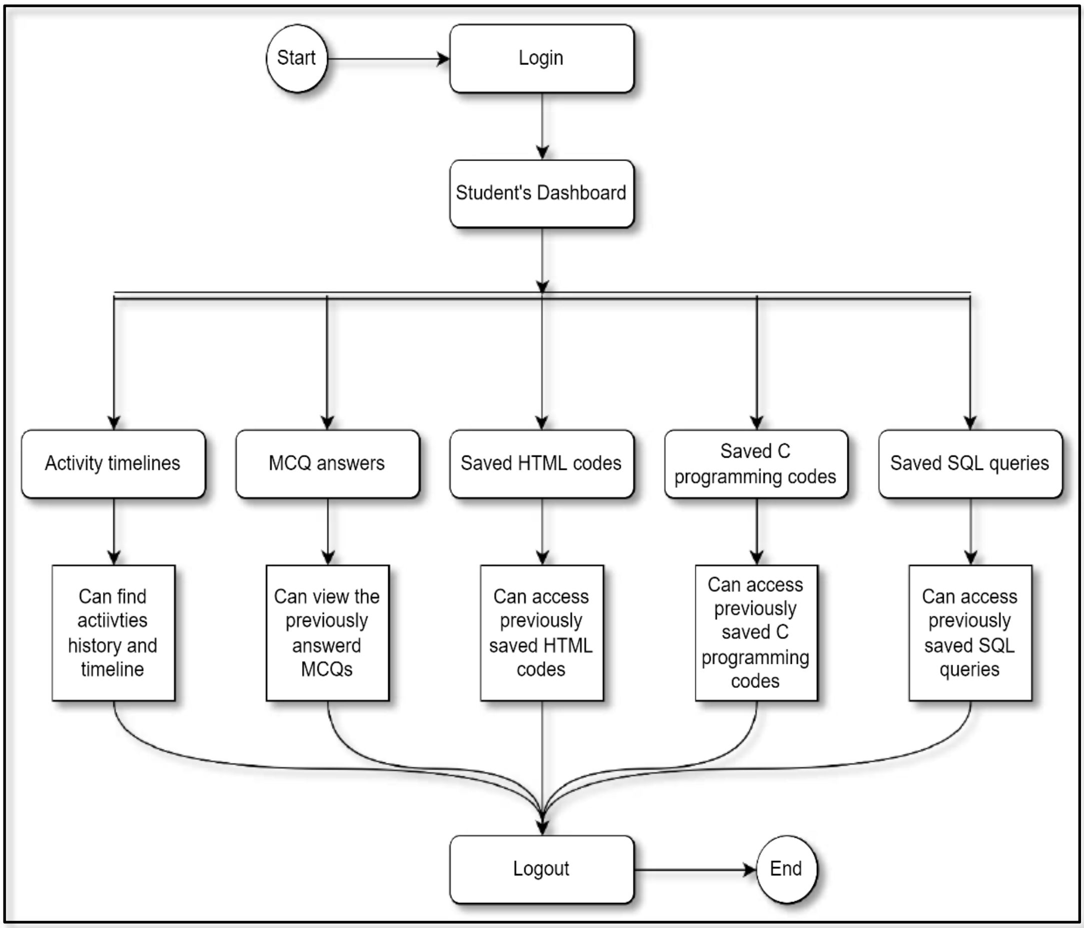


Fig. 3.6: Student’s dashboard activities.

Additionally, students can access the contents of the system any time via computer or mobile phones and enjoy the live coding facility. Students will also be able to submit their assignments online that was prepared by their teachers Fig. 3.7. They will also be able to give their feedback on the course and its contents by participating in survey Fig. 3.8.

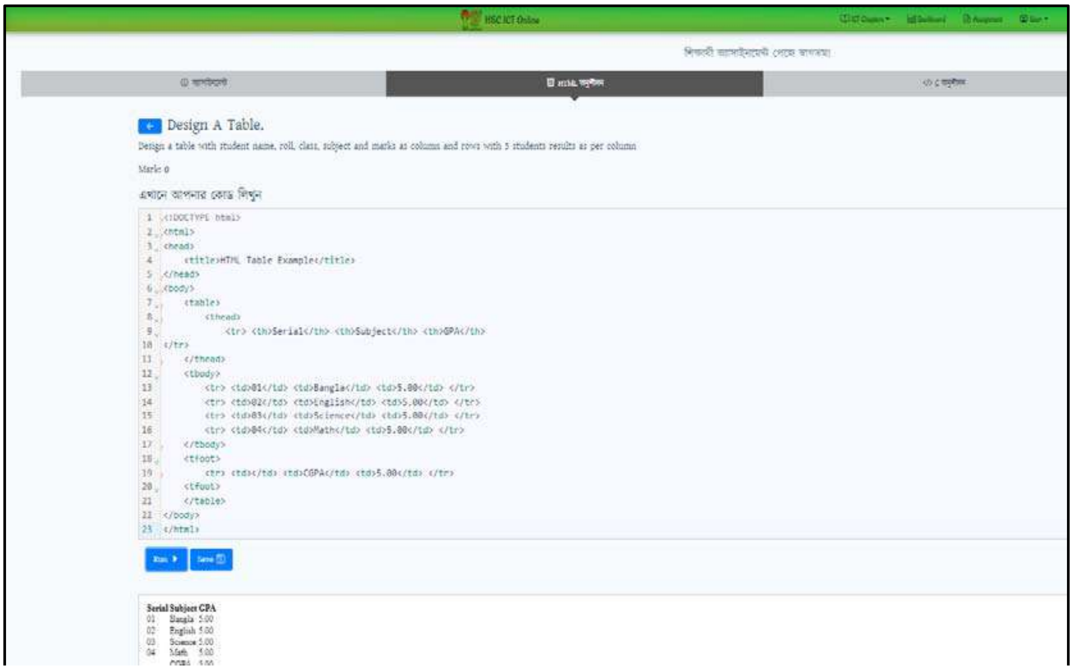


Fig. 3.7: Submission of assignment through online.

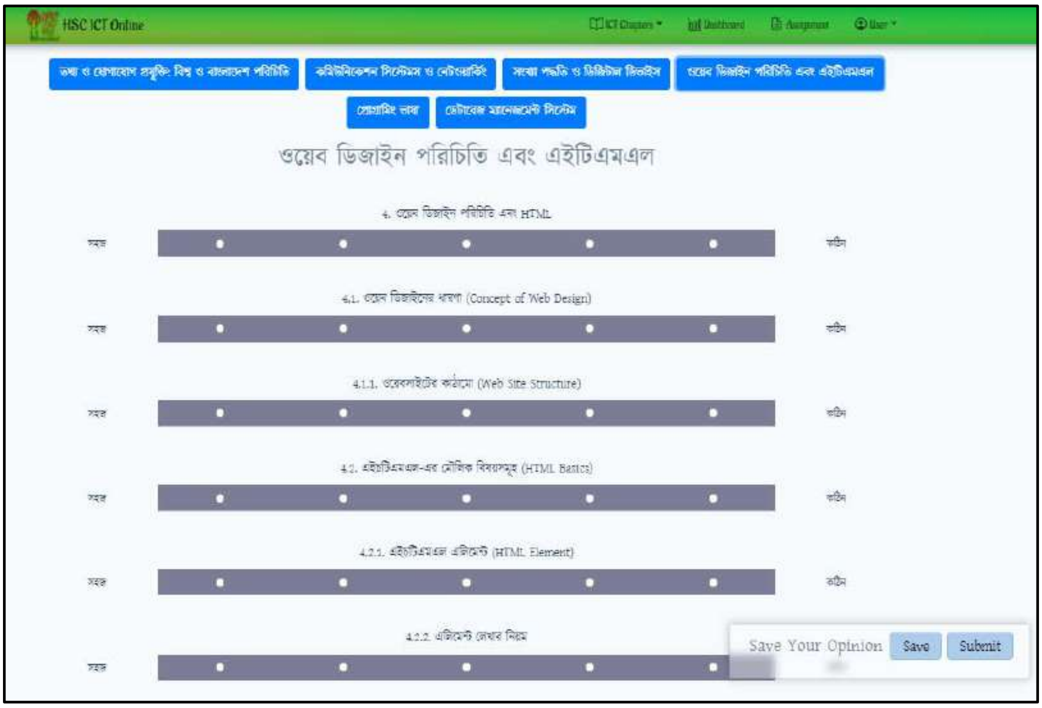


Fig. 3.8: Students feedback on course and the contents.

3.3.2 Teacher’s activities

Teachers are the administrator for monitoring the students, prepare assignments and conducting the evaluations of their respective students. The perform a number of tasks as shown in Fig. 3.9.

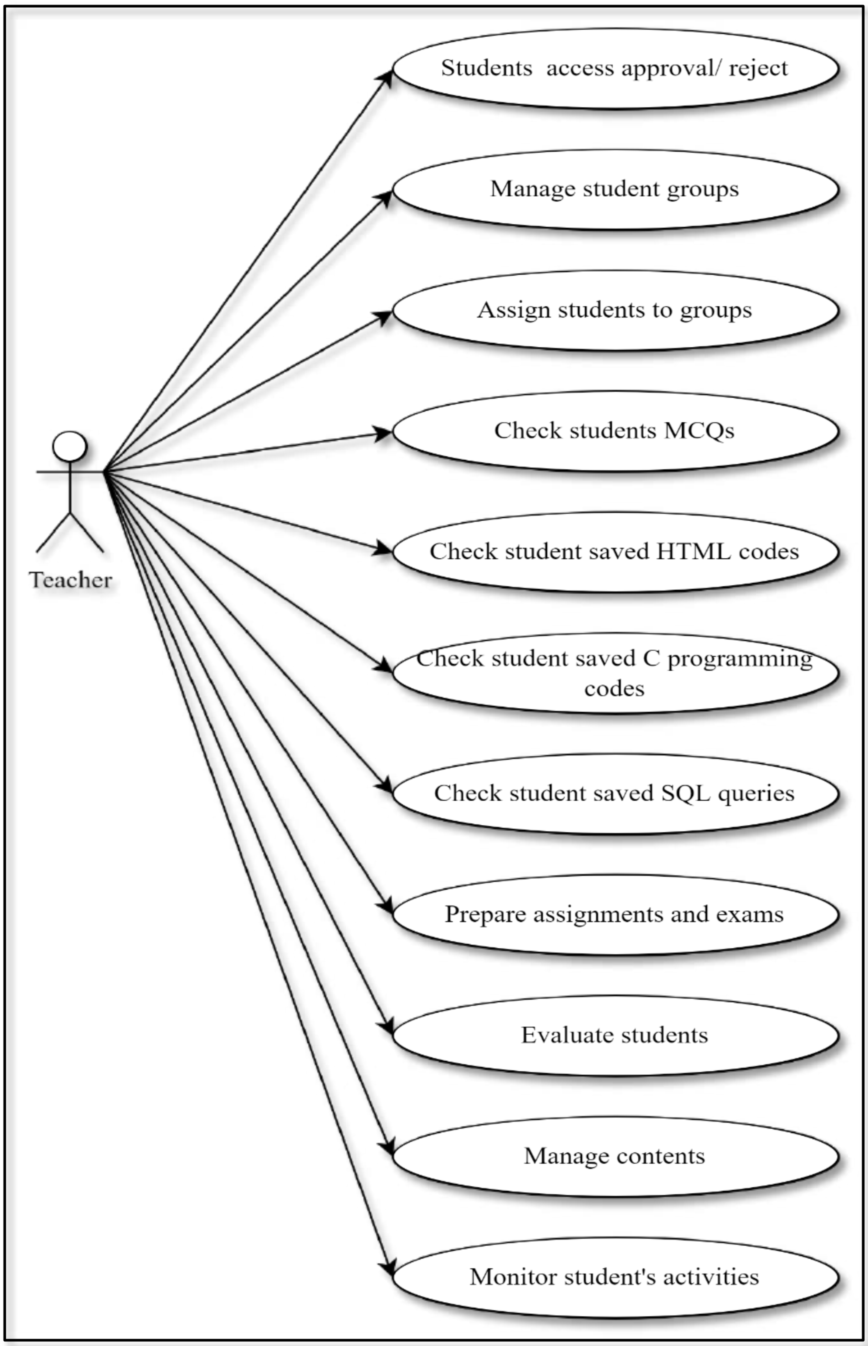


Fig. 3.9: Teacher’s activity diagrams.

They can approve a student request in the system in order to access the system and add him/her to a specific group of students. They also interact with the system modules for inserting the content into content database as per design of the content database, updating the content as per necessity and insert problem to the problem-bank integrating the content with the problem. He can set assignment and set evaluation questions for specific group of students as their requirement and monitor their activity through the help of teacher's dashboard Fig. 3.10.

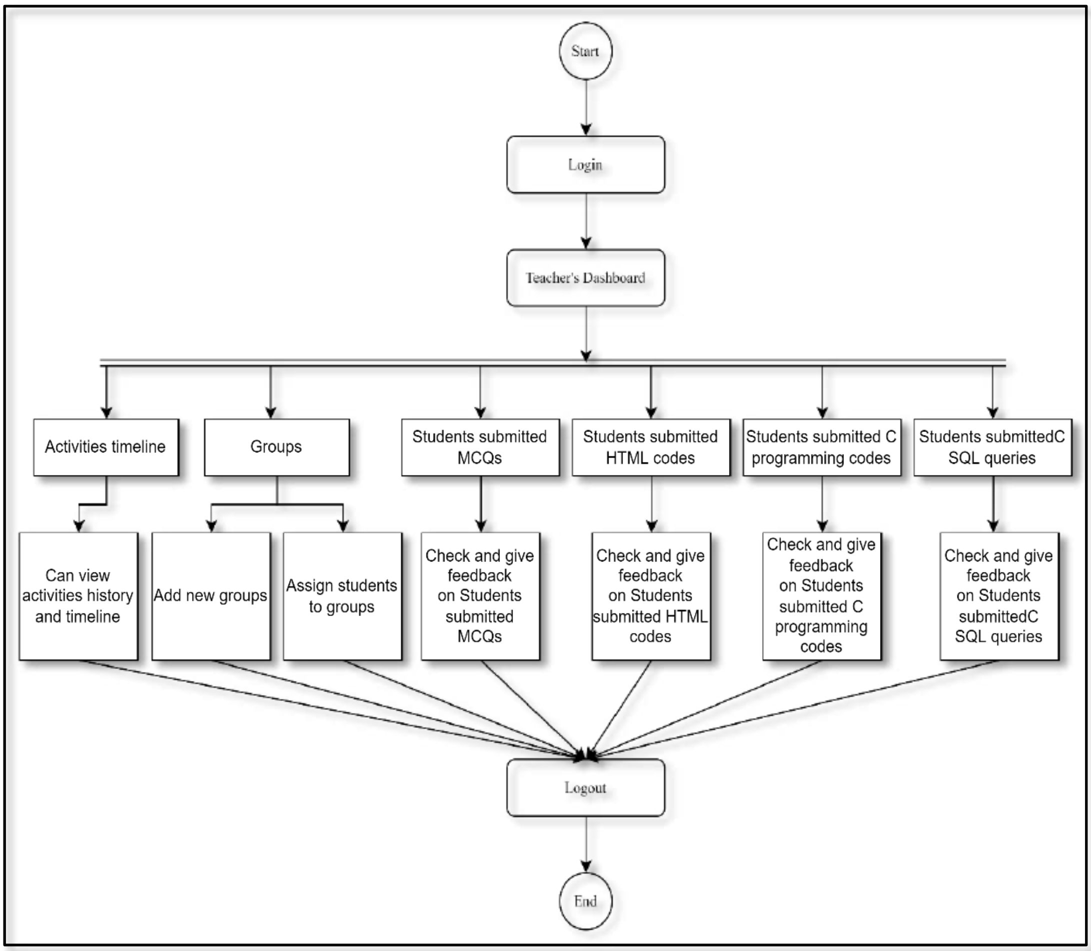


Fig. 3.10: Teacher's dashboard activities.

They also can help the students by checking the answers submitted by the students, evaluate and advising them about the correct answers (Fig. 3.11, Fig. 3.12 , Fig. 3.13).

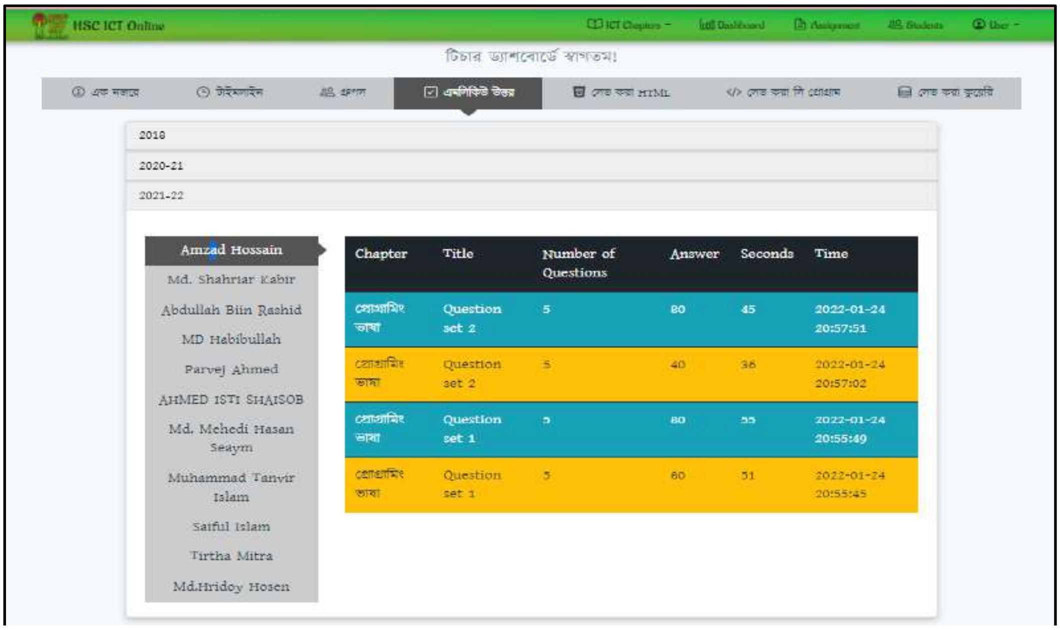


Fig. 3.11: Monitoring students' activities.

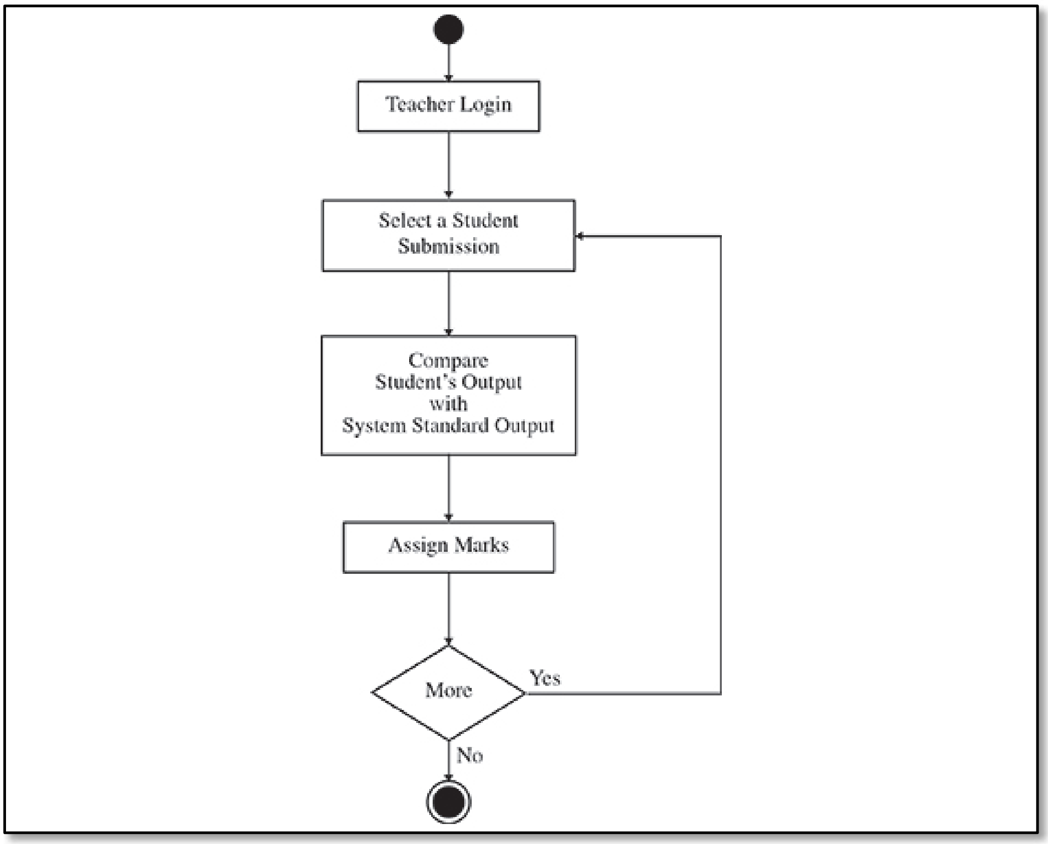


Fig. 3.12: Student answer Evaluation Diagram

Fig. 3.12 - in this diagram we can see the teacher evaluation process for the student answer. Teacher can select student name from the list to see student answer then he

compares the student answer with the standard system output. After analyzing the output of student teacher assigns the marks for that student Fig. 3.13.

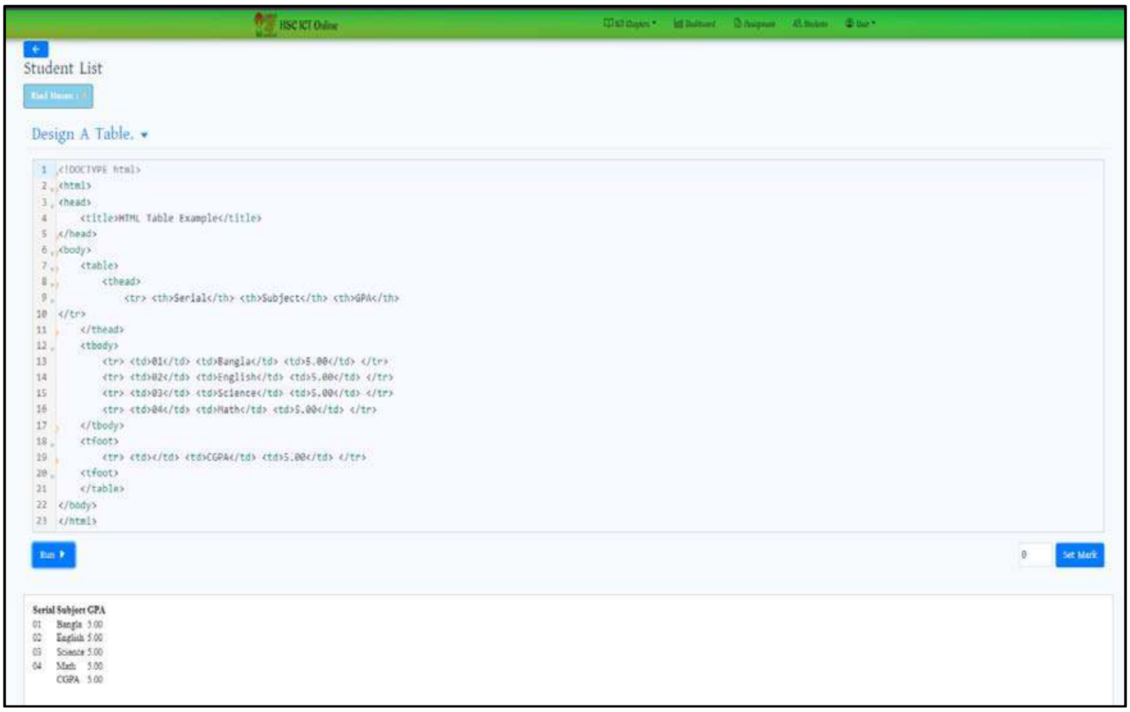


Fig. 3.13: Evaluation of student’s code by teacher.

3.3.3 Teacher’s and student’s interaction

The interactivity between the teacher and student is one of the salient features of the HSC ICT e-Learning System. As shown in Fig. 3.14students get feedback on their activities from the teacher almost in a real time. They can get feedback from their teachers on their saved or submitted html, c programming code and SQL queries which will make them understand the concepts easily. On the contrary, teachers prepare and ask students for assignment and students submits the assignment through the system. Then teacher evaluates the answers and give marks to the answers.

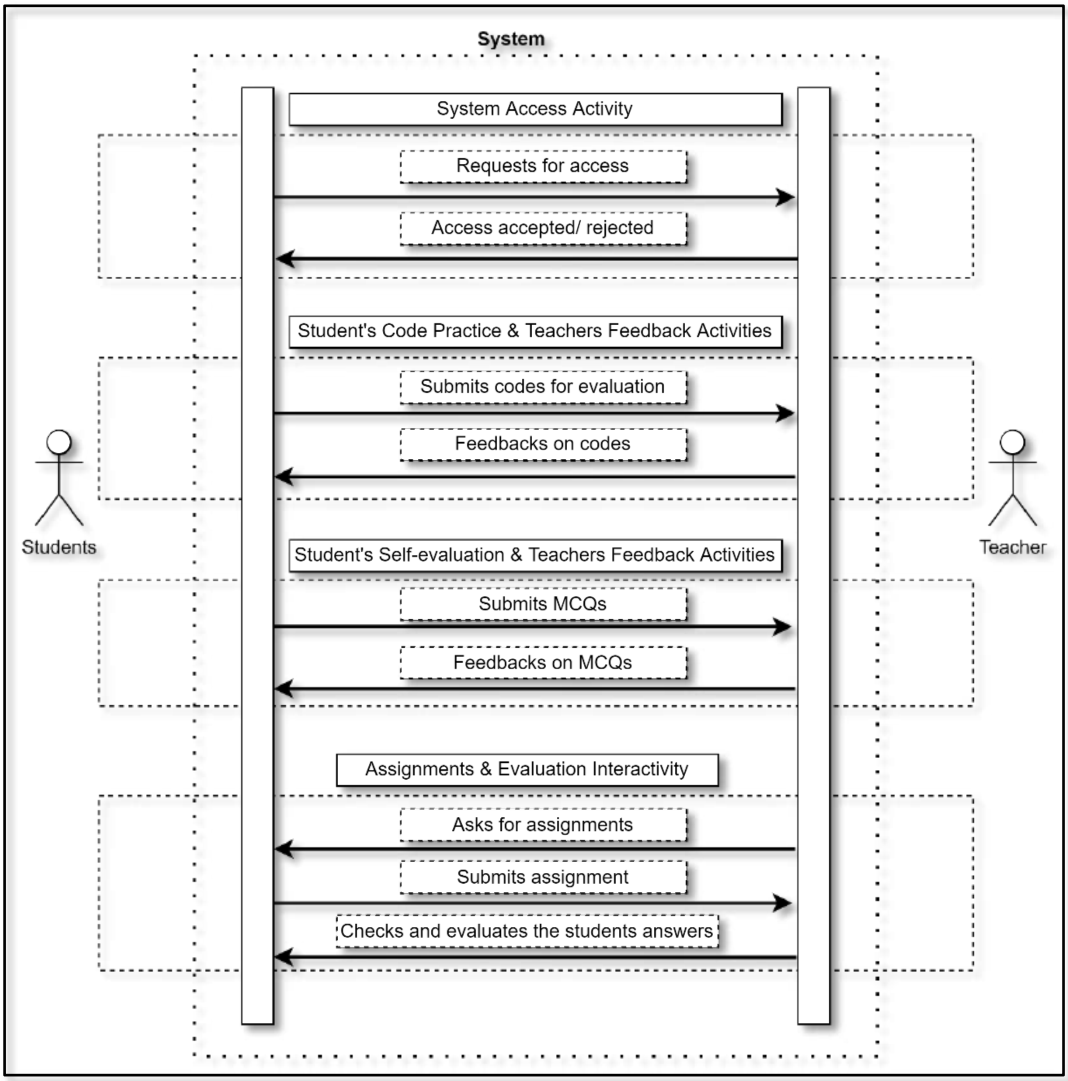


Fig. 3.14: Interaction between teacher and students.

3.3.4 Admin user activities

Admin user can perform a number of activities. He is responsible for adding or updating a college information into the system. He will also interact with the system module for adding and updating learning contents and MCQ question for students' evaluation so that teachers can select questions from question banks. He can approve teachers to administrate their respective students in the system. Admin user also can track and monitor user activities (Fig. 3.16) in the system.

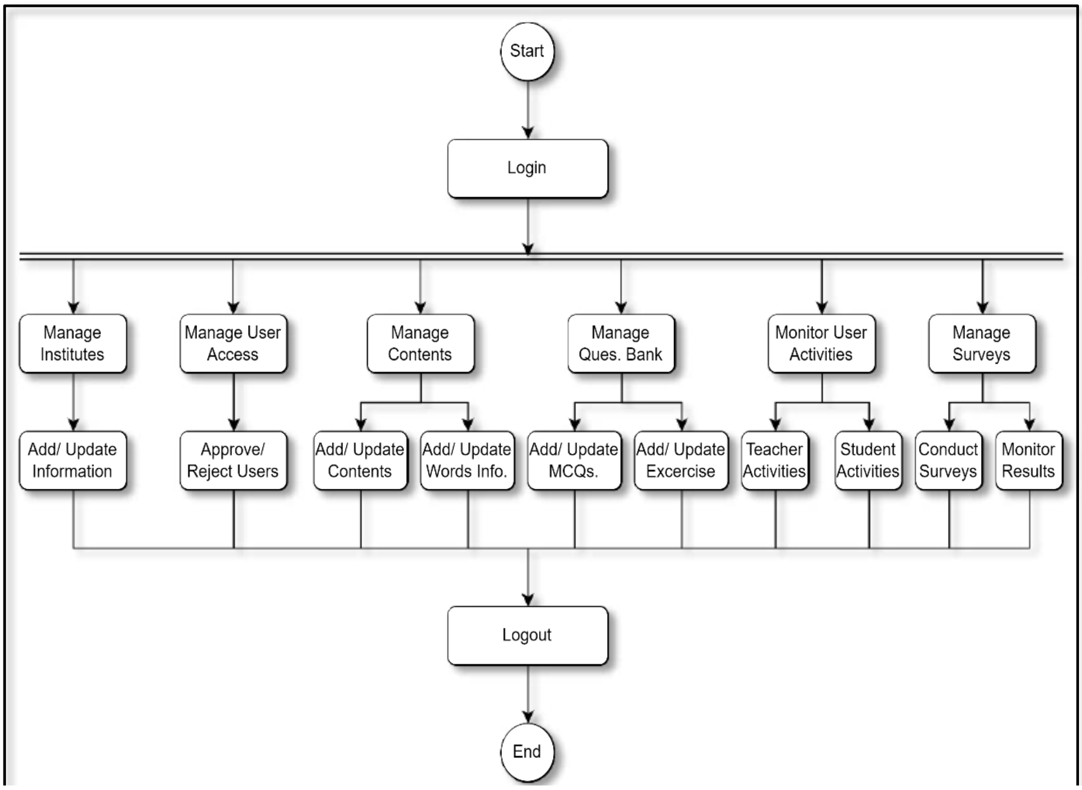
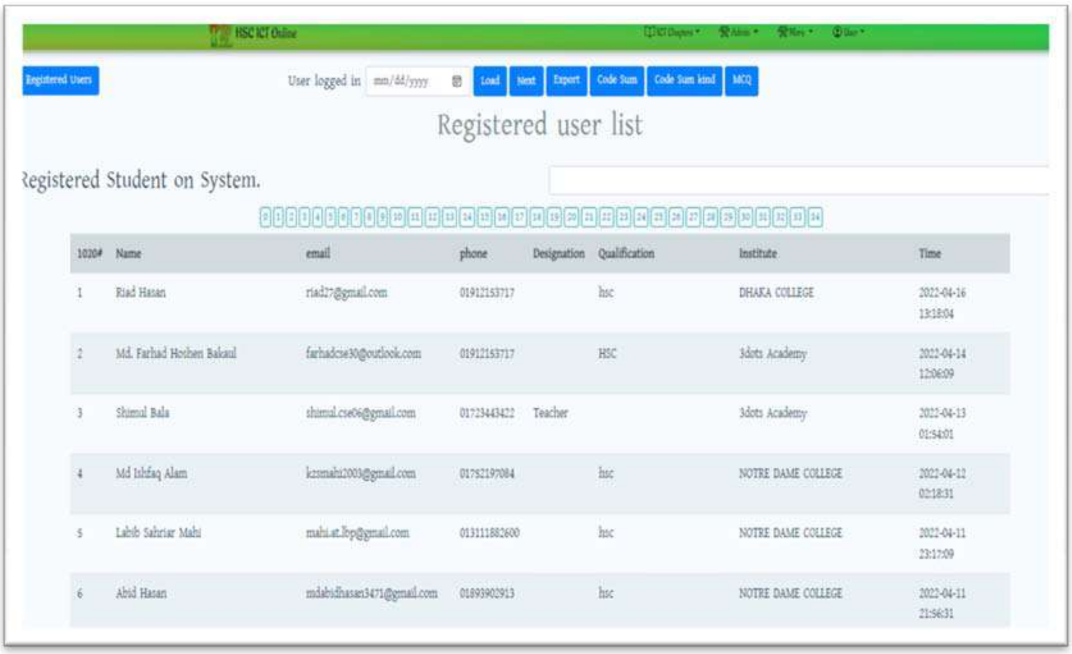


Fig. 3.15: Admin user use-cases.



1020#	Name	email	phone	Designation	Qualification	Institute	Time
1	Riad Hasan	riad27@gmail.com	01912153717		hsc	DHAKA COLLEGE	2022-04-16 13:18:04
2	Md. Farhad HosHen Bakaul	farhadcse30@outlook.com	01912153717		HSC	3dots Academy	2022-04-14 12:06:09
3	Shimul Bala	shimul.cse06@gmail.com	01723443422	Teacher		3dots Academy	2022-04-13 01:54:01
4	Md Ishfaq Alam	kzsmahi2003@gmail.com	01752197084		hsc	NOTRE DAME COLLEGE	2022-04-12 02:18:31
5	Labib Sahriar Mahi	mahi.at.lbp@gmail.com	013111882600		hsc	NOTRE DAME COLLEGE	2022-04-11 23:17:09
6	Abid Hasan	mdabidhasan3471@gmail.com	01893902913		hsc	NOTRE DAME COLLEGE	2022-04-11 21:56:31

Fig. 3.16: Tracking user activities into the system.

He is also be able to conduct surveys and add survey questions for participants.

3.4 Analysis of Cognitive domains

As discussed in previous section, the HSC ICT e-Learning system contains various levels of contents and activities. Students can read through the textual contents for gaining knowledge about a topic which covers the NCTB syllabus, in addition to that, for many of the topic, on hover or mouse click, the system provides some additional information (text, website links, videos) which help him/her to develop his/her understanding of that topic. Ongoing through this, students can apply their learning by practicing through live coding section, they can run the provided code, also they can think of or analyze some new things and evaluate their thinking by code practicing as they can see the outputs of the code immediately. If they can cover all the topics and practice with focus, with the facility of code saving and downloading, they will be able to create a static website which will reflect and enhance their creativity to some extent.

So, we can map the contents and activities to match the cognitive levels as shown in Table 3.1.

Table 3.1: Cognitive level mapping of HSC ICT e-Learning System contents and activities

HSC ICT e-Learning System: Contents and Activities	Cognitive Domain Level
Reading materials, helpful web links, graphical contents.	Remember
Reading materials, helpful web links, graphical contents, MCQ test.	Understand
Do yourself,	Apply
Do yourself, Live coding facility	Analyze
Survey, Problem Based Learning	Evaluate
Problem Based Learning,Assignments	Create

CHAPTER 4
ANALYSIS OF HSC ICT E-LEARNING SYSTEM BASED ON REVISED BLOOM'S TAXONOMY

In this chapter, we will analyze the Revised Bloom's Taxonomy in order to make it applicable for the evaluation of HSC ICT e-Learning System. Then we will work on the Introduction to Web Design and HTML module which is one of the six modules as per the syllabus provided by NCTB for HSC level in Bangladesh. The experiment and analysis in this project will be conducted at multiple levels.

4.1 Revised Bloom's Taxonomy

As it was discussed earlier, Revised Bloom's Taxonomy (RBT) has a two-dimensional architecture. The two dimensions are:

- The cognitive process dimensions
- The knowledge dimensions

The structure of the revised Bloom paradigm is that if we take s grid and along the x axis place the cognitive dimensions and along the y axis the knowledge dimensions, the point where they meet will be the area of attention from the perspective of both parameters. Along the cognitive dimension, for example, may be placed 'remember,' 'understand,' 'apply,' analyze,' 'evaluate' and 'create.' Along the y axis may be placed, for example, the areas of knowledge such as factual knowledge, conceptual knowledge, procedural knowledge and meta-cognitive knowledge as seen in Table 4.1 below [25]. Then the cognitive aspects of each knowledge area can in turn be assessed.

Table 4.1: The two-dimensional structure of Revised Bloom's Taxonomy

Knowledge Dimension	**Cognitive Process Dimension** Low order thinking skill → High order thinking skill					
	Remember	*Understand*	*Apply*	*Analyze*	*Evaluate*	*Create*
Factual knowledge						
Conceptual knowledge						
Procedural knowledge						
Metacognitive knowledge						

Each interception in the table is equivalent to the intended learning objectives and includes some subject content and a description of what should be done with or for that content. The objectives are defined in a content and in a cognitive process: respectively a noun (or a substantive phrase) and a verb (or a verbal phrase) [7].

4.2 Content Identification

In the beginning, we have thoroughly studied through the contents of the HSC ICT e-Learning System and the HSC ICT text book. We divided the module into content groups and uniquely identified all the contents of each group.

4.3 Content Classification According to RBT

Churches had identified the digital tools and verbs associated with each level, that is, lower to higher [26] as shown in Fig. 4.1.

THE COGNITIVE PROCESS DIMENSION	THE KNOWLEDGE DIMENSION			
	Metacognitive	Procedural	Conceptual	Factual
Remember	Recall	Recognise	List	Remember
Understand	Predict	Clarify	Classify	Summarise
Apply	Use	Carry Out	Provide	Respond
Analyse	Deconstruct	Integrate	Differenciate	Select
Evaluate	Reflect	Judge	Determine	Check
Create	Create	Design	Assemble	Generate

Fig. 4.1: Verbs used for classification in Revised Bloom's Taxonomy

Fisher has suggested using cognitive and knowledge dimension of Bloom's Taxonomy in writing distance learning objectives with the sample verbs like in Table 4.2.

Table 4.2: Cognitive and knowledge dimension in Bloom's Taxonomy.

Knowledge Dimension	**Cognitive Process Dimension**					
	Remember	***Understand***	***Apply***	***Analyze***	***Evaluate***	***Create***
Factual knowledge	List	Summarize	Classify	Order	Rank	Combine
Conceptual knowledge	Describe	Interpret	Experiment	Explain	Asses	Plan
Procedural knowledge	Tabulate	Predict	Calculate	Differentiate	Conclude	Compose
Metacognitive knowledge	Appropriate Use	Execute	Construct	Archive	Action	Actualize

Following the above examples, we collected and aggregated 83 RBT verbs (Table 4.3) according to Cognitive Process dimension and knowledge dimension shown in Fig. 4.1 and Table 4.2. and performing further analysis [23].

Table 4.3: Knowledge dimension and Cognitive level wise verbs distribution

		Cognitive Process Dimension					
Knowledge Dimension		Remember	Understand	Apply	Analyze	Evaluate	Create
	Factual	1. List 2. Recite 3. Define 4. Know	13. Summarize 14. Explain 15. Paraphrase	26. Respond 27. Classify 28. Apply 29. Modify	42. Select 43. Order 44. Relate	56. Check For 57. Rank 58. Critique 59. Appraise	72. Generate 73. Combine 74. Produce
	Conceptual	5. Recognise 6. Describe	16. Classify 17. Interpret 18. Show	30. Provide 31. Experiment 32. Design 33. Use Facts	45. Differentiate 46. Explain 47Investigate 48. Compare	60. Determine 61. Asses 62. Compare 63. Explain	75. Assemble 76. Plan 77. Organize
	Procedura	7. Recall 8. Tabulate 9. Outline 10. Reproduce	19. Clarify 20. Execute 21. Demonstrate 22. Rewrite	34. Carry 35. Calculate 36. Demonstrate 37. Solve	49. Integrate 50. Illustrate 51.Discover 52. Analyze	64. Judge 65. Conclude 66. Check 67. Evaluate	78. Design 79. Compose 80.Develope
	Metacognitive	11. Identify 12. Proper Uses	23. Predict 24. Understand 25. Generalize	38. Use 39. Construct 40. Discover 41. Produce	53. Construct 54. Separate 55. Achieve	68. Reflect 69. Decide 70. Action 71. Criticise	81. Create 82.Actualize 83. Reconstruct

So then, we classified them according to RBT using verbs that fit in for every content. For each content, we tried to figure out the number of possible RBT verbs and assigned to them. Revised Bloom Taxonomy is used for classifying the contents in meta-cognitive (learning to learn) knowledge level.

Assumption:

We assume that, the cognitive knowledge level of a content upgrades with the number of verbs could be used to asked questions on that content. The more the verbs it support the higher is its cognitive knowledge level.

4.4 Analysis Methods

After content identification and segregation, we classified them according to RBT using verbs that fit in for every content. For each content, we tried to figure out the Specifying the knowledge level of a content is not a simple process and is fraught with uncertainty. In these circumstances, fuzzy logic can be the solution [27]]. In this approach, six fuzzy weights have been specified to indicate the knowledge level of contents in learning the Web Design and HTML, namely, Remember (R), Understand (U), Apply (Ap), Analyze (Az), Evaluate(E) and Create(C). Each fuzzy weight is represented by trapezoidal membership functions. These functions are described by four boundary values (a1, a2, a3, and a4): the degree of membership increases between a1 and a2 from 0 to 1, flattens having a degree of 1 between a2 and a3, then decreases between a3 and a4 from 1 to 0. The reason why trapezoidal membership functions were chosen is because at each category of knowledge level, there is an interval (i.e., between a2 and a3) where content scores fully belong to the category. Fig. 4.2 depicts their scheme.

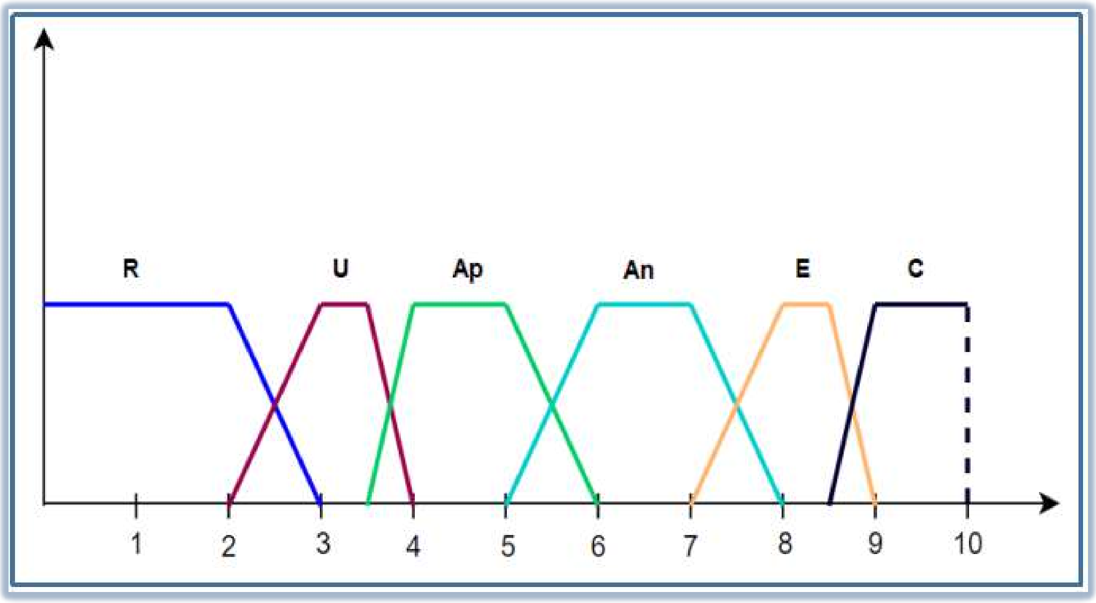


Fig. 4.2: Schema of Fuzzy Weights

To determine the fuzzy weights of each RBT level, the difference of the Upper Limit (U) and Lower Limit (L) is calculated. After that, the weight for each cognitive level namely Factual (W_f), Conceptual (W_c), Procedural (W_p), Metacognitive (W_m) is calculated according to each RBT level separately by dividing the individual RBT level fuzzy weighs(W_i) by number of cognitive level(C_n). It gives a value for each cognitive level for every other RBT levels. For example, Factual (W_{rf}) = W_r/C_n where Wrf = Factual Level weight, C_n = 4 (No of total Cognitive Level), W_r = Fuzzy weight of Remember.

Afterwards, for assigning a value to a verb belonging to a RBT level along with Cognitive Level, the weight of a cognitive level (W_{rici}, eg. W_{rf}) is divided by the number of verbs (V_n) belonging to that section.

Finally, to calculate the value of an RBT level, total weights of each cognitive level

(W_{rici}) is summed up and the the Lower Limit of that RBT level is added. The equation becomes as follows.

$$Wr_i = R_l + \sum_{i=0}^{n} \mathrm{Wr_i c_i} \qquad \text{(i)}$$

Example: $W_r = RL + W_{rf} + W_{rc} + W_{rp} + W_{rm}$

In order to calculate the total value, all the values of each RBT level is summed up. Hence the equation becomes.

$$W = \sum_{i=0}^{n} Wr_i \qquad \text{(ii)}$$

Example: $W = W_r + W_u + W_{ap} + W_{an} + W_e + W_c$

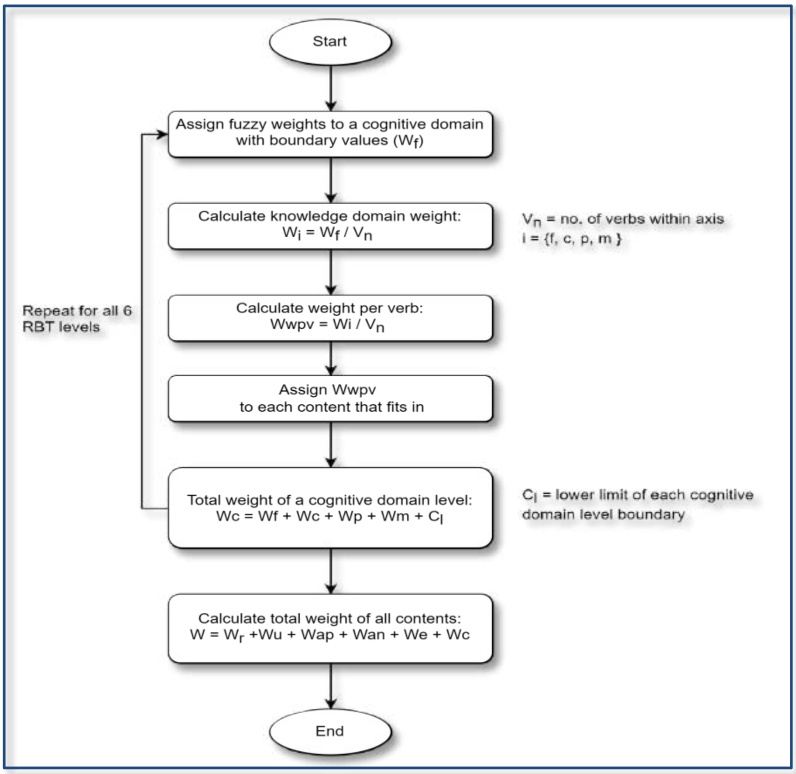


Fig. 4.3: Applying Fuzzy Weights

Fig. 4.3 shows the step by step process for measuring each verb's cognitive weight and calculating the contents cognitive knowledge level discussed above.

In the second method, the fuzzy weight assignment is done from lower to higher level, the weights are assigned as for Remember = 1, Understand = 1, Apply =1, Analyze = 2, Evaluate =2 and Create =3. For Cognitive level weights are assigned as for Factual = 1, Conceptual =2, Procedural =3 and Metacognitive = 4. Both are taken within the range of 10 to maintain the proportion uniform. Afterwards, for assigning a value to a verb belonging to a RBT level along with Cognitive Level, the weight of a cognitive level (Wrici, eg. Wrf) is divided by the number of verbs (Vn) belonging to that section and multiplied with that level's weight value. The assignments are shown in Fig. 4.4.

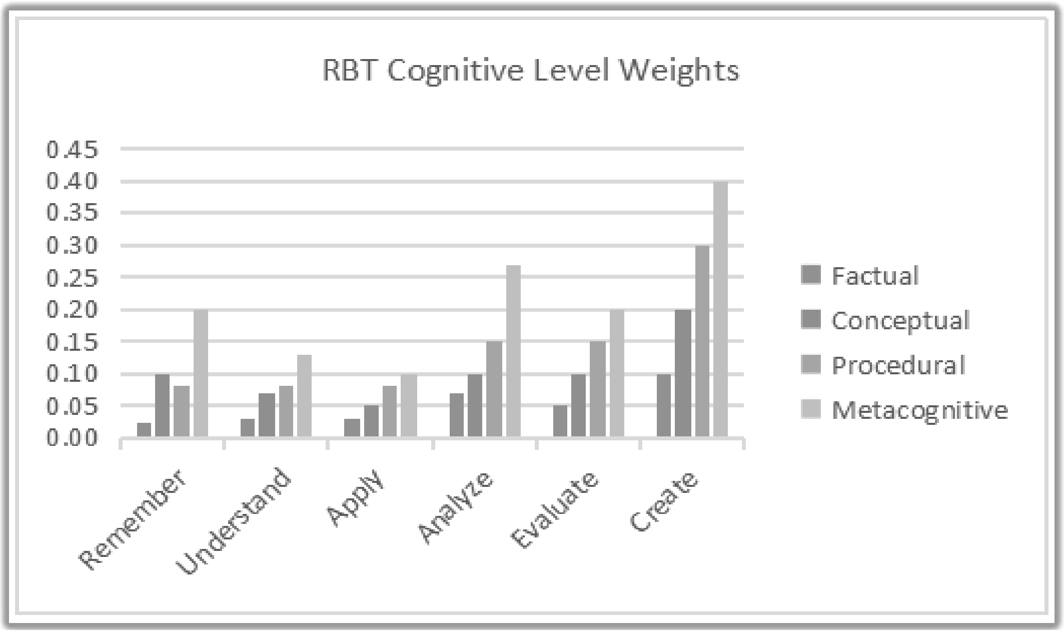


Fig. 4.4: Schema of Fuzzy Weights (Method II)

4.5 System Evaluation

In order to evaluate the system, we conducted a three-day workshop where the students of five of the renowned college inside Dhaka participated. Before taking user feedback on the systems based on their experience of the system, we conducted a pre feedback session where 10 question was set such a way to evaluate the feasibility and necessity of an eLearning System for HSC ICT students. The questioners for pre feedback session are as Table 4.4. Table 4.5 shows the 19 questionnaires for the evaluation of HSC ICT Online eLearning System. Also, to evaluate the students' performance on before and after using the system, we set 3 questions and got feedback before and after the workshop as Table 4.6. For the evaluation of the system, seven aspects have been considered: usability, effectiveness, contents, and learner's satisfaction, eLearning System to traditional method comparison and practical orientation, cognitive domain. The participants were 48 students from five different colleges inside Dhaka. Fig. 4.5 shows the student's feedback feature.

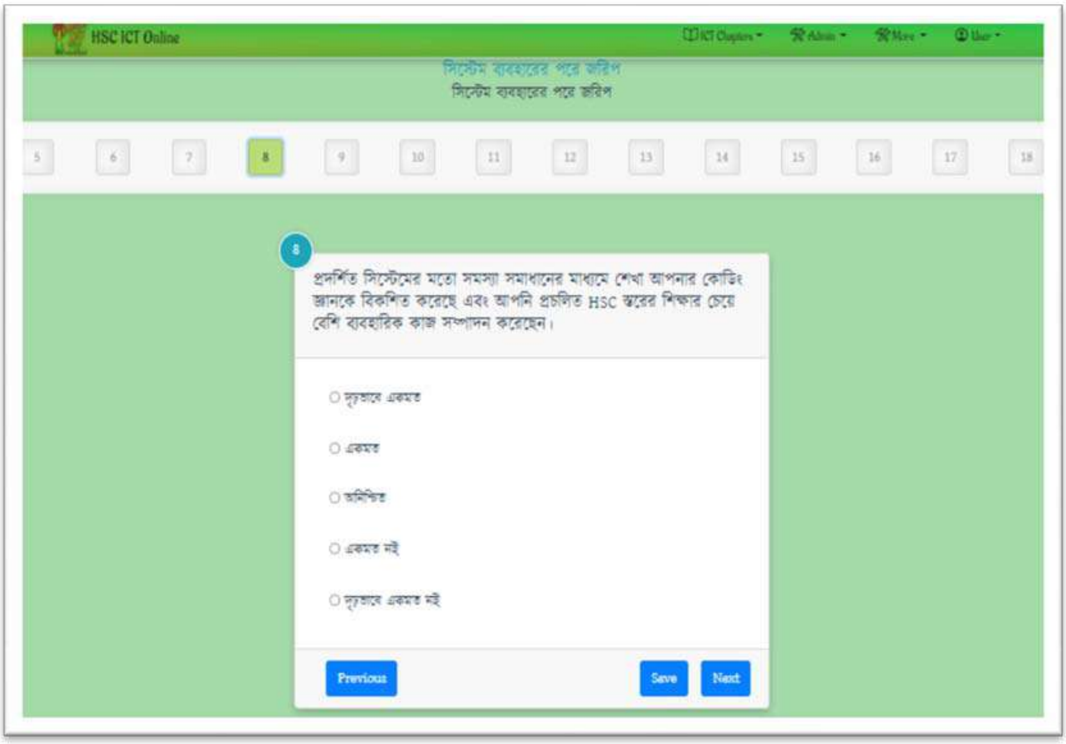


Fig. 4.5: Students Feedback on HSC ICT e-Learning System.

Table 4.4: Student's Feedback Questions on e-Learning System (Before using HSC ICT e-Learning System)

Question No	Question
Q 01	Do you think the ICT course is interesting?
Q 02	Are you satisfied with learning the ICT course in the usual way?
Q 03	Do you think the traditional textbook system is enough to teach ICT courses effectively?
Q 04	Do you think the ICT course is practical oriented?
Q 05	Do you think that the practical elements of ICT course should be learned in a practical way?
Q 06	Do you think learning to practice is more effective?

Q 07	Do you think that an interactive system can help you learn ICT courses?
Q 08	Do you think that one of the tools that can help you learn on your own is to help you learn ICT courses?
Q 09	Do you think that "learning through problem solving" will enhance your qualifications?
Q 10	Do you think online practice can help you learn more efficiently?

Table 4.5: Student's Feedback Questions on eLearning System (After using eLearning System)

Student's Feedback Questions on eLearning System		
Q 1	The eLearning System is easy and comfortable to use and well-designed	Usability
Q 2	You are satisfied and confident with the instructions and functions of the shown system	
Q 3	You are satisfied with interactive facilities and the new presentation method of the shown system.	Interactivity/ Effectiveness of the Environment
Q 4	The environment of the given system improves your thinking and problem-solving skills.	
Q5	The learning methodology was appealing and motivating and made learning fun.	
Q6	You believe the contents of the shown system are sufficiently informative and well organized.	Contents/ Material
Q7	Online practice helped you to learn more efficiently.	
Q8	Online version is easy to read then the text book	
Q9	The addition of the system can improve the students understanding in class room learning for the HSC level.	eLearning System vs Traditional
Q10	I prefer to learn using traditional materials then the eLearning System.	
Q11	Compare to traditional method eLearning System takes less time to learn.	

Q12	You intend to use the shown system as learning assisted tool frequently.	Learner's Satisfaction/ Learning Outcome
Q13	The system will be an attractive solution to motivate and engage the students to self-learning for the HSC level.	
Q14	Problem solving of the system inspired and helped you for more learning.	
Q15	The practical components of ICT course should be learnt in an interactive mode like the shown e-learning system.	Practical Orientation
Q16	Learning by problem solving like the shown system has developed your HTML knowledge and you performed more HTML practical work more than traditional HSC level learning.	
Q17	Use of HSC ICT Online System helps in acquiring programming skills and acquiring innovative skills	Cognitive Domain
Q18	Doing it yourself will increase the ability to do something new according to the reading of the book	
Q19	Through HSC ICT Online System it is possible to acquire knowledge to solve new programming problems	

Table 4.6: Student's Feedback Questions on skill levels (After using eLearning System)

Students Skill Level	
Q1	How familiar are you with HTML?
Q2	How familiar are you with C Programming?
Q3	How familiar are you with Database?

CHAPTER 5

RESULTS AND DISCUSSION

In this chapter, we will discuss about the analysis and finding about the performance of HSC ICT e-Learning System. In order to analyze the contents, we used MySQL database to store and analyze the data.

5.1 Evaluation of Contents

By separating the module into content groups and uniquely identified all the contents of each group It was found that 26 content was commonly covered by both book and e-Learning System, 10 unique contents in book, 16 unique contents in e-Learning System i.e. Total of 52 unique contents. The findings are presented in Table 5.1.

Table 5.1: Content of HSC ICT e-Learning System and the HSC ICT text book

Scope	No. of Content Groups	No. of Contents
Book	17	36
HSC ICT Online	17	42

Fig. 5.1 shows that as the book has 19% unique contents and the online learning system has 31% of unique contents, there is a scope of improvement for both of them.

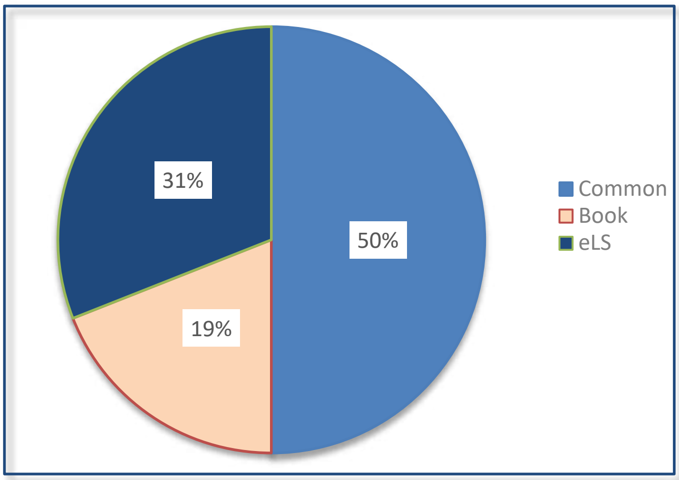


Fig. 5.1: Contents distribution comparison of HSC ICT e-Learning System and the HSC ICT text book

After analyzing with the application of the first proposed method and calculating the values, we get some very interesting results.

Table 5.2: Cognitive level wise rating of HSC ICT e-Learning System and the HSC ICT text book

RBT Level	HSC ICT Online	Text Book
Remember	12.73	14.06
Understand	81.62	81.7
Apply	215.94	190.32
Analyze	25.95	15.57
Evaluate	21.39	0
Create	43.54	0

Table 5.2 shows the comparison between total content valuations for each RBT Cognitive levels. It is found that the book contents are somewhat has better knowledge level in Remember level, in Understand level both are almost same, but in the rest of the four RBT level, LS has better contents knowledge level. Fig. 5.2 represent the result in graphical mode.

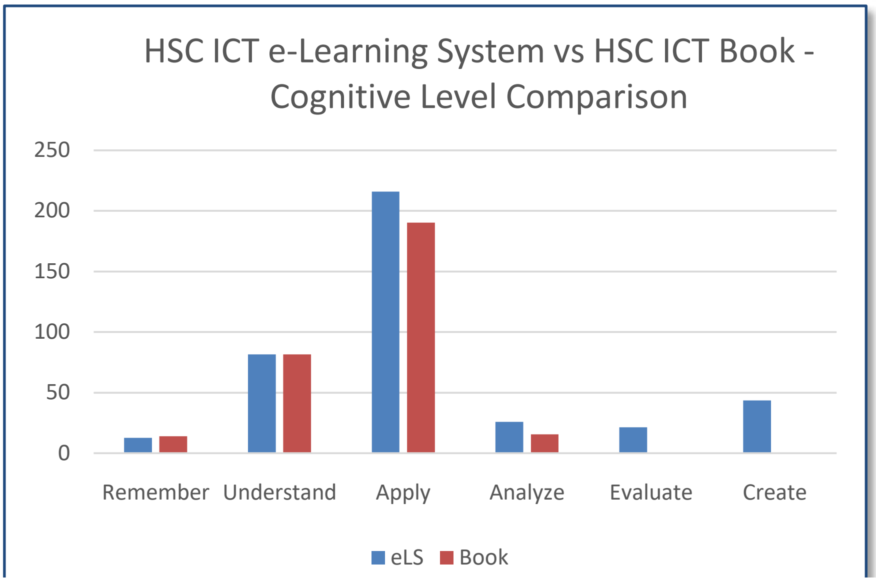


Fig. 5.2: RBT cognitive level wise rating: HSC ICT text book vs HSC ICT e-Learning System.

In further analysis, from Table 5.3 and corresponding Fig. 5.3 shows that, in RBT Knowledge Domain Levels, books content have better knowledge level in Remember_Factual, Remember_Conceptual, Remember_Procedural, Understand_Factual, Understand_Metacognitive, Apply_Procedural levels, and in rest of the levels, eLS contents are clearly ahead.

Table 5.3: Knowledge domain level wise rating of HSC ICT e-Learning System and the HSC ICT text book

RBT Knowledge Domain Level	HSC ICT Online	Text Book
Remember_Factual	2.85	3.23
Remember_Conceptual	9.12	9.88
Remember_Procedural	0.38	0.95
Remember_Metacognitive	0.38	0
Understand_Factual	21.7	26.04
Understand_Conceptual	4.34	2.17
Understand_Procedural	44.73	40.47
Understand_Metacognitive	10.85	13.02

Apply_Factual	84.18	65.88
Apply_Conceptual	3.66	3.66
Apply_Procedural	65.88	69.54
Apply_Metacognitive	62.22	51.24
Analyze_Conceptual	15.57	10.38
Analyze_Procedural	10.38	5.19
Evaluate_Conceptual	14.26	0
Evaluate_Metacognitive	7.13	0
Create_Conceptual	17.26	0
Create_Procedural	17.39	0
Create_Metacognitive	8.89	0
	401.17	301.65

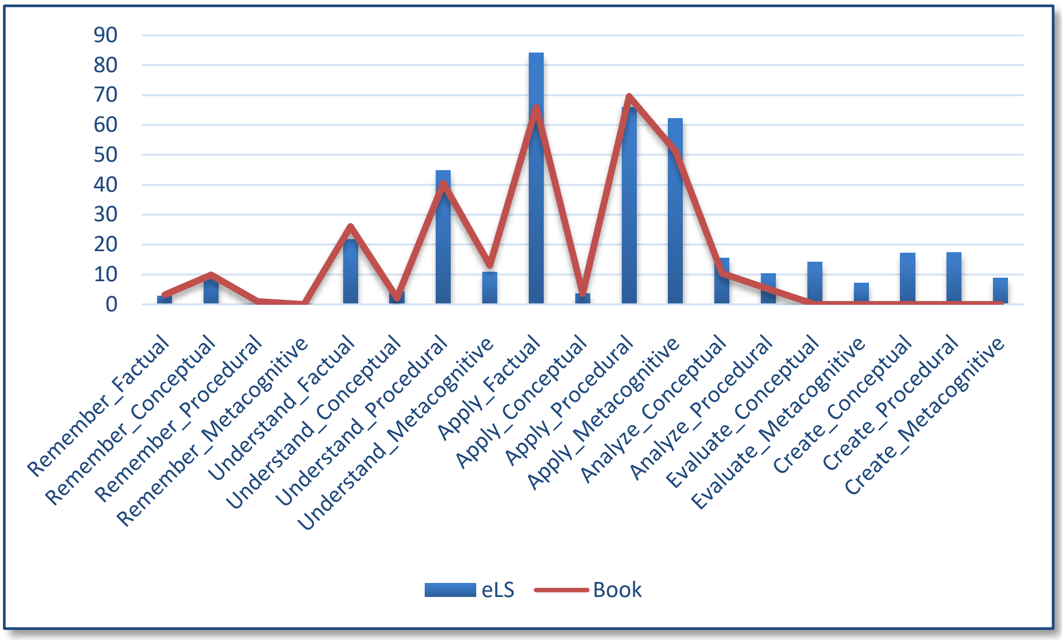


Fig. 5.3: RBT Knowledge Domain level wise rating of HSC ICT e-Learning System and the HSC ICT text book.

By comparing the content level shown in Fig. 5.4 it justifies that there exist some common contents and unique contents in book and online learning system,

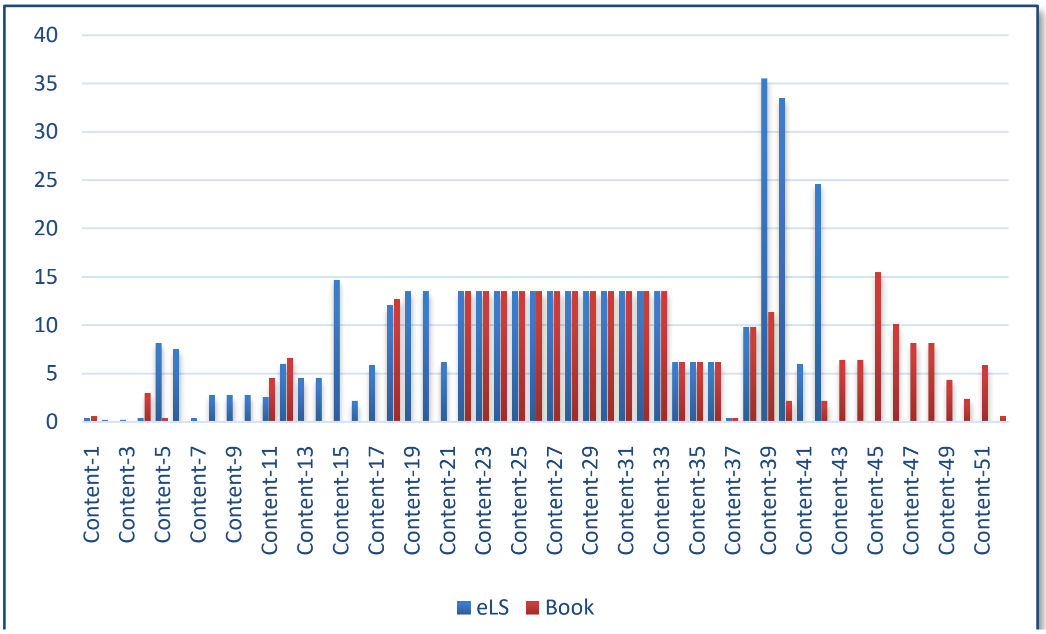


Fig. 5.4: Content level wise comparison of HSC ICT e-Learning System and the HSC ICT text book.

After thorough analysis using the proposed first method, we also applied the proposed second method and found similar kind of response.

Table 5.4: Content of HSC ICT e-Learning System and the HSC ICT text book (Method II)

RBT Level	HSC ICT Online	Text Book
Remember	3.21	3.51
Understand	78.77	78.73
Apply	210.38	185.51
Analyze	25.6	15.35
Evaluate	21.4	0
Create	45	0

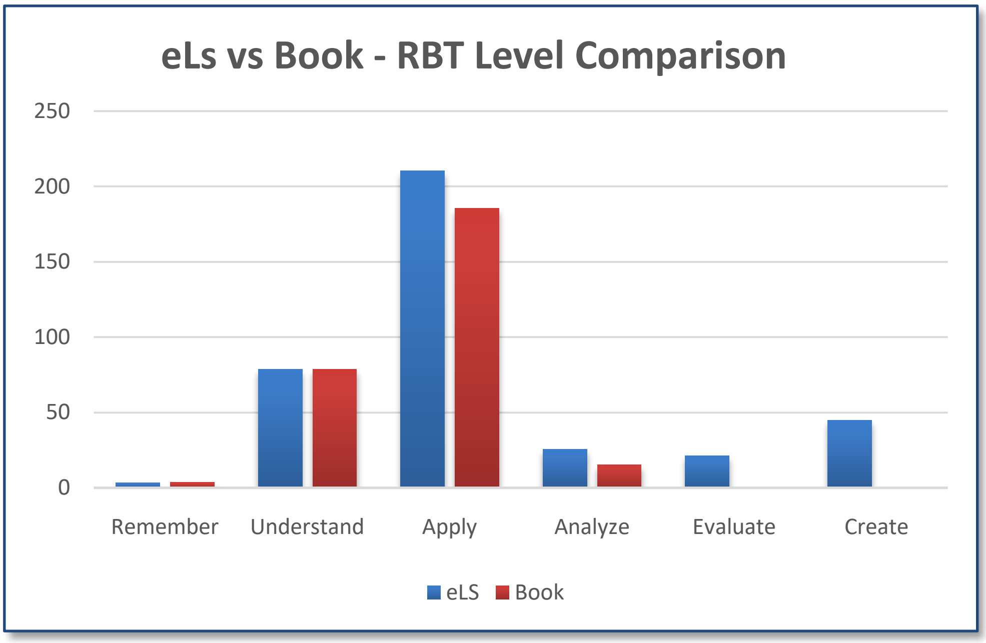


Fig. 5.5: RBT cognitive level wise rating: HSC ICT text book vs HSC ICT e-Learning System (Method II).

Table 5.4 shows the comparison between total content valuations for each RBT levels. It is found that the book contents are somewhat has better knowledge level in Remember level, in Understand level both are almost same, but in the rest of the four RBT level, LS has better contents knowledge level. The graphical representation shown in Fig. 5.5.

In further analysis, from Table 5.5 and corresponding Fig. 5.6 shows that, in RBT Knowledge Domain Levels, books content have better knowledge level in Remember_Factual, Remember_Conceptual, Remember_Procedural, Understand_Factual, Understand_Metacognitive, Apply_Procedural levels, and in rest of the levels, eLearning System contents are clearly ahead.

Table 5.5: Knowledge dimension level wise rating of HSC ICT e-Learning System and the HSC ICT text book (Method II)

RBT Knowledge Domain Level	HSC ICT Online	Text Book
Remember_Factual	0.45	0.51
Remember_Conceptual	2.4	2.6

Remember_Procedural	0.16	0.4
Remember_Metacognitive	0.2	0
Understand_Factual	20.3	24.36
Understand_Conceptual	4.14	2.07
Understand_Procedural	43.68	39.52
Understand_Metacognitive	10.65	12.78
Apply_Factual	81.19	63.54
Apply_Conceptual	3.55	3.55
Apply_Procedural	64.44	68.02
Apply_Metacognitive	61.2	50.4
Analyze_Conceptual	15.3	10.2
Analyze_Procedural	10.3	5.15
Evaluate_Conceptual	14.2	0
Evaluate_Metacognitive	7.2	0
Create_Conceptual	17.4	0
Create_Procedural	17.9	0
Create_Metacognitive	9.7	0
	384.36	283.1

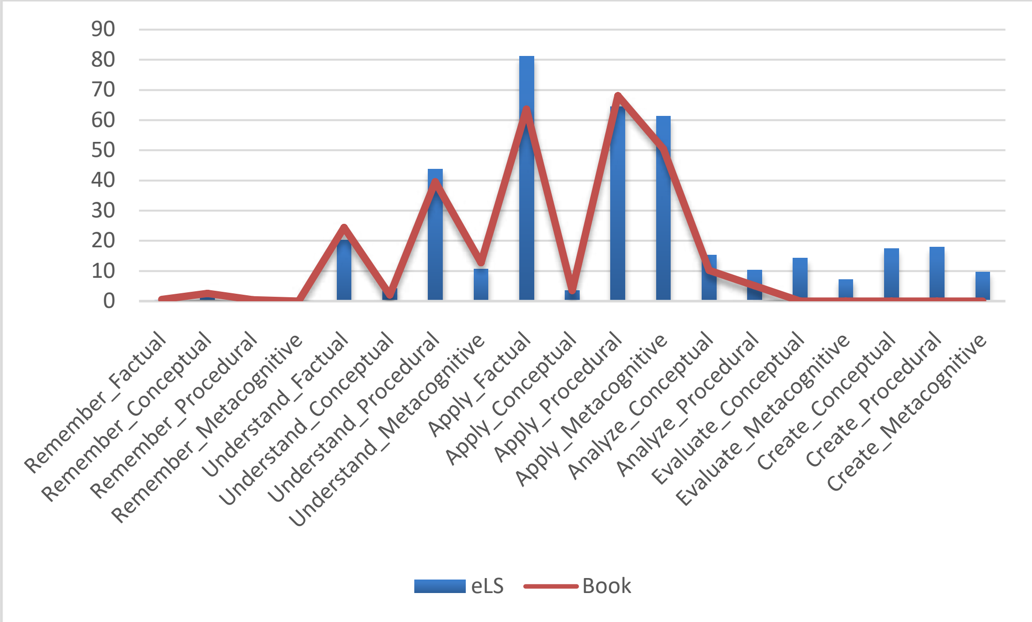


Fig. 5.6: RBT Knowledge Domain level wise rating: Book vs HSC ICT Online system (Method II).

We further dig down to the content level and found a clear picture of the difference in contents knowledge level between reference textbook and the HSC ICT eLearning System as shown in Fig. 5.7.

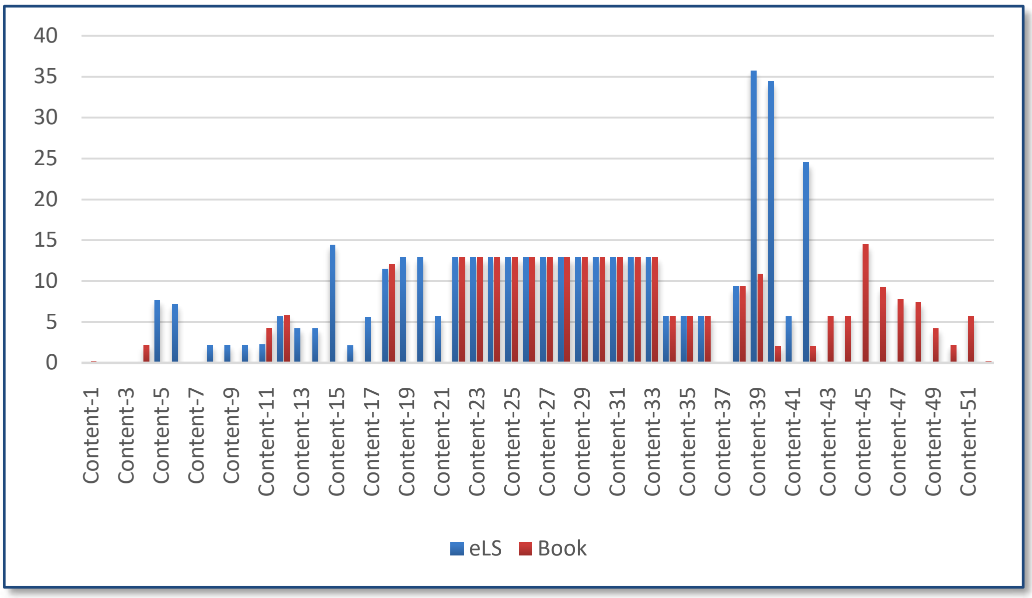


Fig. 5.7 Content level wise comparison: Book vs HSC ICT Online system (Method II).

From the analysis, it is noticed that, the books contents have slightly better knowledge level from theoretical aspect but the eLearning System contents are ahead in practical aspect.

5.2 Evaluation of the System

In order to assess student satisfaction in domain knowledge adaptation, the statistical hypothesis was employed, comparing the presented system to its conventional version. As such, after the completion of the course at the end of the semester, the students were asked to answer based on the Likert scale from "Strongly agree" (7) to "Strongly disagree" (1) the questionnaires above mentioned.

The scale used here for student feedback is shown in Table 5.6.

Table 5.6: Likert scale evaluation parameters.

Strongly Agree	Agree	Unsure	Disagree	Strongly Disagree

However, the feedback from the students after the three days' workshop on the use of HSC ICT eLearning System was taken and analyzed. 42 students from 6 different colleges had participated in the workshop. Most of the students had already studied the contents of HSC ICT course in traditional classroom approach in their college. The demographic information of the students is shown in Fig. 5.8.

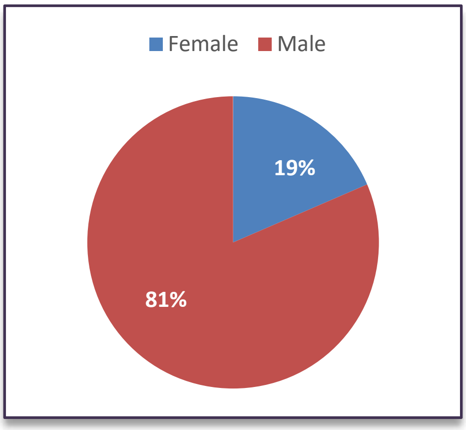


Fig. 5.8: Gender wise students

The feedback from the students was inspirational. The pre feedback emphasizes on the feasibility and necessity of an eLearning system for HSC ICT students. Table 5.7 shows the pre feedback results.

Table 5.7: Feedback result of necessity and feasibility of an eLearning System for HSC ICT course

No.	Question	Agree
Q1	Do you think the ICT course is interesting?	92.68%
Q2	Are you satisfied with learning the ICT course in the usual way?	47.50%
Q3	Do you think the traditional textbook system is enough to teach ICT courses effectively?	12.20%
Q4	Do you think the ICT course is practical oriented?	84.21%
Q5	Do you think that the practical elements of ICT course should be learned in a practical way?	97.44%
Q6	Do you think learning to practice is more effective?	94.87%
Q7	Do you think that an interactive system can help you learn ICT courses?	92.11%
Q8	Do you think that one of the tools that can help you learn on your own is to help you learn ICT courses?	78.95%
Q9	Do you think that “learning through problem solving” will enhance your qualifications?	97.37%
Q10	Do you think online practice can help you learn more efficiently?	95.12%

From the Table 5.7, it can be seen than only 47% student are satisfied with the traditional text book-based learning of ICT course but 88% are thinking that textbook based learning is not enough for learning ICT (Q2) course effectively (Q3). On the other hand, over 90% students give an opinion that having a good interactive eLearning System might help them to learn more effectively and enhance their skill (Q5, Q6, Q9, and Q 10). The result is presented graphically in Fig. 5.9.

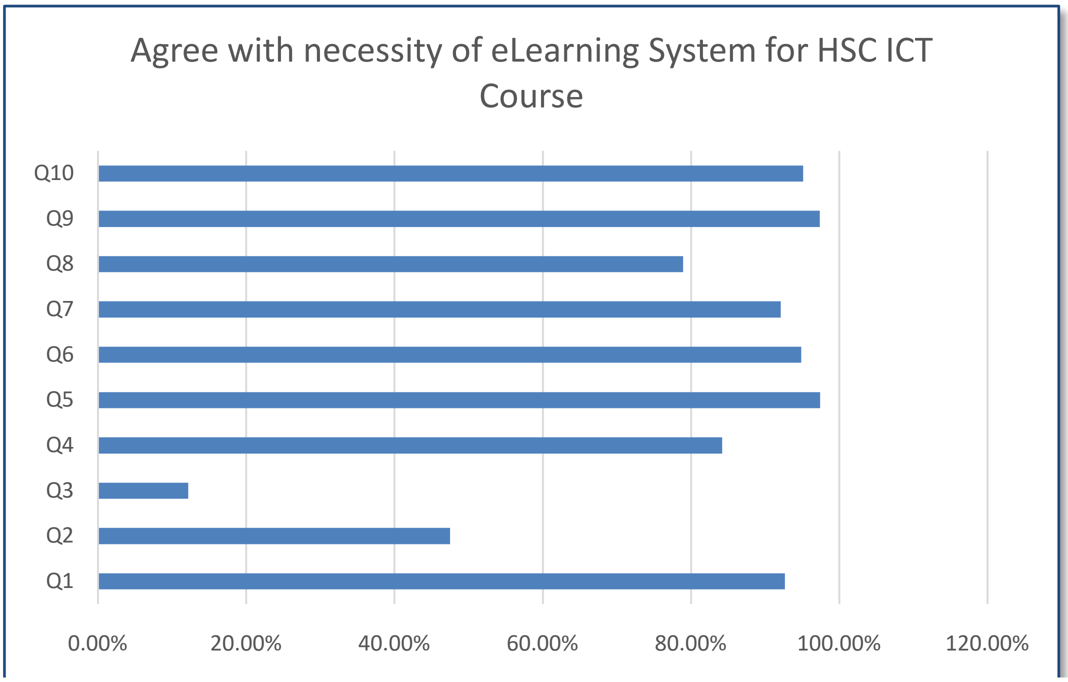


Fig. 5.9: Feedback result of necessity and feasibility of an eLearning System for HSC ICT course**.**

However, the feedback from the students after the three days' workshop on the use of HSC ICT eLearning System was taken and analyzed. The analysis gives an insight on the different aspect of the eLearning System. The result in shown in Table 5.8.

Table 5.8: Feedback result after workshop

Student's Feedback Questions on eLearning System			Positive
Q 1	The eLearning System is easy and comfortable to use and well-designed	Usability	93.55%
Q 2	You are satisfied and confident with the instructions and functions of the shown system		83.87%
Q 3	You are satisfied with interactive facilities and the new presentation method of the shown system.	Interactivity/ Effectiveness of the Environment	93.55%
Q 4	The environment of the given system improves your thinking and problem-solving skills.		90.32%
Q5	The learning methodology was appealing and motivating and made learning fun.		93.55%

Q6	You believe the contents of the shown system are sufficiently informative and well organized.	Contents/ Material	93.55%
Q7	Online practice helped you to learn more efficiently.		90.32%
Q8	Online version is easy to read then the text book		70.97%
Q9	The addition of the system can improve the students understanding in class room learning for the HSC level.	eLearning System vs Traditional	87.10%
Q10	I prefer to learn using traditional materials then the eLearning System.		38.71%
Q11	Compare to traditional method eLearning System takes less time to learn.		80.65%
Q12	You intend to use the shown system as learning assisted tool frequently.	Learner's Satisfaction/ Learning Outcome	100.00%
Q13	The system will be an attractive solution to motivate and engage the students to self-learning for the HSC level.		96.77%
Q14	Problem solving of the system inspired and helped you for more learning.		96.77%
Q15	The practical components of ICT course should be learnt in an interactive mode like the shown e-learning system.	Practical Orientation	90.32%
Q16	Learning by problem solving like the shown system has developed your HTML knowledge and you performed more HTML practical work more than traditional HSC level learning.		67.74%
Q17	Use of HSC ICT Online System helps in acquiring programming skills and acquiring innovative skills	Cognitive Domain	90.32%
Q18	Doing it yourself will increase the ability to do something new according to the reading of the book		93.55%
Q19	Through HSC ICT Online System it is possible to acquire knowledge to solve new programming problems		93.55%

From the Table 5.8 it can be seen that approximately above 85% students gave positive impression on the usability of the HSC ICT eLearning System, over

90% students thinks that the system is very interactive, over 90% thinks that the course material is well organized and even 70% thinks that the readability of the system is better than the text book. 100% of the students want the system to be used as complementary to the traditional system and most importantly over 90% of them thinks that the use of eLearning System may enhance their thinking skill (Cognitive Domain).

However, the last but not the list aspect of the analysis was to determine if the system upgrades the student's skill to learn programing language. The comparison between before and after workshop is shown in Fig. 5.10. From the figure it can be seen that 23% students had no knowledge or skill of any programming, 44% had some familiarity, 21% had beginner level knowledge and 10% had advance level knowledge. After using the system their skill upgraded to the level that all of them got familiar with the programming language, 26% stayed at the beginner level but 69% skilled up to beginner level. Although only 3% of the students' things that advance level skill and knowledge can be achieved through the system.

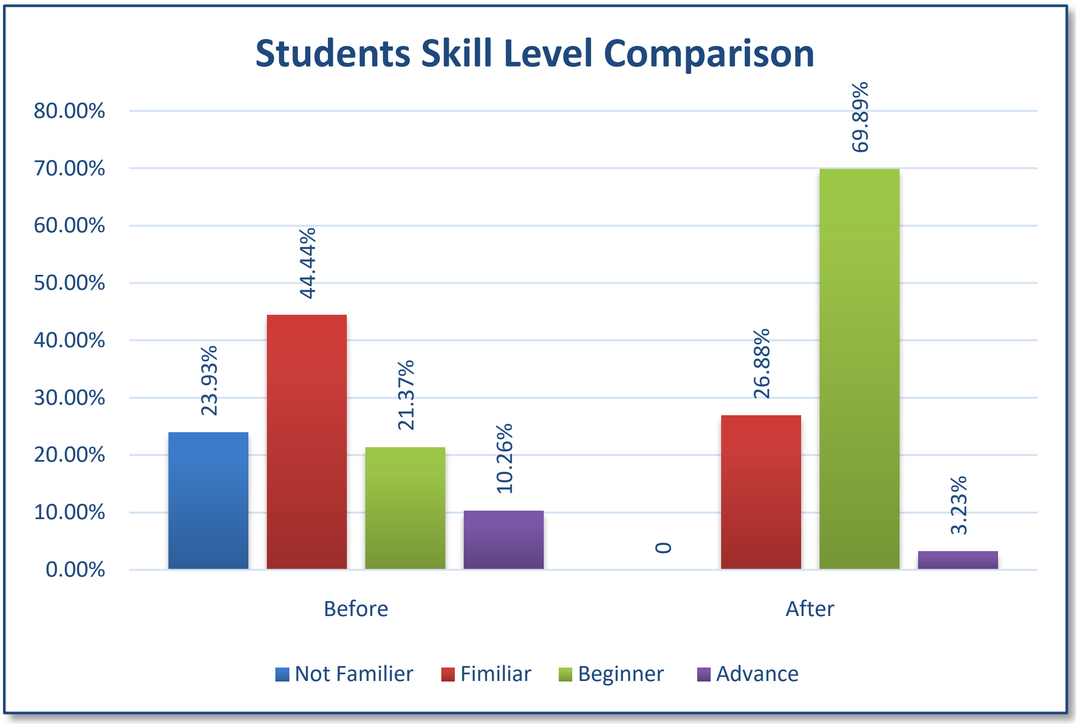


Fig. 5.10: Skill level comparison between before and after workshop.

CHAPTER 6
CONCLUTION

In the project, we have presented the architectural analysis of HSC ICT e-Learning System which is based on Problem-Based eLearning (PBeL) model for learning and teaching of ICT course in higher secondary level. We have also performed various performance analysis of the system based on Revised Bloom's Taxonomy. We also performed usability and interactivity test based on user feedback. The analysis was performed to measure the effectiveness of the system in teaching and learning the ICT course.

During the analysis, the architectural design of the system was found to be efficiently constructed to match with the cognitive domain levels of Revised Bloom's Taxonomy. For performance analysis, initially the contents of the system and textbook was categorized using the verbs of Revised Bloom's Taxonomy and then some fuzzy weights were applied to measure and calculate the value of each content. Then the contents of the e-learning system and the textbook was compared. In the comparison, it was found that the e-learning system covered 31% more unique contents then the text book. It was also found that the higher order cognitive domain levels covered by the e-learning system is better than the textbook while the lower order cognitive levels are similar for both the case. It indicates that the use of the e-learning system along the textbook, may enhance the creativity of the student.

For the usability and the effectiveness measurement, we conducted a three days' workshop on teaching and learning using HSC ICT e-Learning system. From there, we have collected feed-back from a number of college students and teachers of various colleges. From pre-workshop survey, it was found that over 90% students felt the necessity of an interactive e-learning system for learning a practical course like ICT even before using the system.

While, after using the system, above 85% students provided positive impression on the usability of the HSC ICT e-Learning System and over 90% students think that the use of this e-learning system may enhance their thinking skill.Almost all of the students wanted the system to be used as complementary to the traditional system.

Also, a significant change in their skill level was observed. We have found that 29% unfamiliar students got familiar with the programming concepts and there was a rise in beginner skill level up to 69% after participating in the workshop.

There are some scopes of improvement of the system as suggested by the participants of the workshops. These are the use of more video, animation etc. in contents that can be implemented in the future work. Also, based on the analysis, individualized learning path might be created for the students based on their knowledge and skill level and incorporate with the e-Learning system.

References

[1] Khalid and B. Abdullah, "Barriers to the Successful Integration of ICT in Teaching and Learning Environments: A Review of the Literature,"*Eurasia Journal of Mathematics Science & Technology Education*, vol. 5, no. 3, pp. 235-245, 2009.

[2] M. S. H. Khan, M. Hasan and C. K. Clement, "Barriers to the Introduction of ICT into Education in Developing Countries: The Example of Bangladesh,"*International Journal of Instruction*, vol. 5, no. 2, 2012.

[3] G. M. M. Bashir and A. S. M. L. Hoque, "An effective learning and teaching model for programming languages,"*Journal of Computers in Education*, vol. 3, no. 4, p. 413–437, 2016.

[4] T. I. Rafi, T. S. Subeen, F. Manjor, N. A. Siddiqi and L. Rahman, "Introduction to web design and HTML," in *Information and Communication Technology*, Dhaka, NCTB, 2020, pp. 115-148.

[5] B. A. Khan, M. H. S. Kuofie and S. Suman, Future Opportunities for Using Gamification in Management Education, USA: IGI Global, 2021.

[6] B. S. Bloom, M. D. Engelhart, E. J. Furst, W. H. Hill and D. R. Krathwohl, Taxonomy of educational objectives: The classification of educational goals. Handbook 1: Cognitive domain, New York: David McKay, 1956.

[7] D. R. Krathwohl, "A revision of Bloom's taxonomy: An overview, theory into practice,"*Theory into practice*, vol. 41, no. 4, pp. 212--218, 2002.

[8] T. Scott, "Bloom's taxonomy applied to testing in computer science classes,"*Journal of Computing in Small Colleges*, vol. 19, no. 1, pp. 267-274, 2003.

[9] R. Lister and J. Leaney, "Introductory programming, criterion-referencing," in *SIGCSE '03: Proceedings of the 34th SIGCSE technical symposium on Computer science education*.

[10] Oliver, D. a. Dobele, T. a. Greber, M. a. Roberts and Tim, "This course has a Bloom Rating of 3.9,"*Proceedings of the Sixth Australasian Conference on*

Computing Education-Volume 30, pp. 227--231, 2004.

[11] S. K. C. D. K. P. Ankur Joshi, "Likert Scale: Explored and Explained,"*British Journal of Applied Science & Technology,* vol. 7, no. 4, pp. 396-403,, 2015.

[12] M. T. Islam, Rahman, S. a. Galib, K. Syed Md and Uddin and G. Bashir, "Design and implementation of web based collaborative learning model for ict course of college student in bangladesh,"*International Journal of Computer Science and Mobile Computing,* vol. 3, no. 1, pp. 393--400, 2014.

[13] M. H. Mahi, T. Tarannoom, M. A. Islam and M. M. Khan, "A web based interactive system to promote ict education in Bangladesh," in *2019 14th International Conference on Computer Science \& Education (ICCSE)*, 2009.

[14] G. M. M. Bashir and A. S. M. L. Hoque, "PROBLEM-BASED ELEARNING OF HTML IN ICT COURSE OF,"*International Journal of Advances in Electronics and Computer Science,* vol. 4, no. 2, pp. 2393-2835, 2017.

[15] B. B. Chua and L. E. Dyson, "Applying the ISO 9126 model to the evaluation of an e-learning system," 2004.

[16] G. Roberts, "An evaluation of use of Blackboard VLE in first year,"*Core business modules,* 2002.

[17] S. a. K. R. Ozkan, "Multi-dimensional evaluation of E-learning systems in the higher education context: An empirical investigation of a computer literacy course," in *2009 39th IEEE Frontiers in Education Conference*, San Antonio, 2009.

[18] S. Silaban, F. Doringin and N. Tarigan, "eLearning System Evaluation: A Case Study Based on ARO Gapopin's Lecturer's Experiences," in *2020 6th International Conference on Education and Technology (ICET)*, 2020.

[19] A. Al-Alwani, "Evaluation criterion for quality assessment of E-learning content,"*E-Learning and Digital Media,* vol. 11, no. 6, pp. 532--542, 2014.

[20] S. Diana, "Evaluation of E-Learning Application System Performance Based on the Users' Perceptions Case study at Bina Nusanata University," in *2013 IEEE International Conference on Teaching, Assessment and Learning for Engineering (TALE)*, Kuta, Indonesia, 2013.

[21] D. Y. S. a. Y.-S. Wang, "Multi-criteria evaluation of the web-based e-learning system: A methodology based on learner satisfaction and its applications,"*Computers & Education,* vol. 50, p. 894–905, 2008.

[22] R. L. Keeney and H. Raiffa, Decisions with Multiple Objectives: Preferences, New York: Cambridge University Press, Cambridge, 1976.

[23] N. Munkhtsetseg, D. Garmaa and S. Uyanga, "Multi-criteria comparative evaluation of the E-learning systems: A case study," in *2014 7th International Conference on Ubi-Media Computing and Workshops*, 2014.

[24] N. Adams, "Bloom's taxonomy of cognitive learning objectives,"*Journal of the Medical Library Association,* vol. 103, no. 3, pp. 152-153, 2015.

[25] Razmjoo, S. Ayatolah and E. Kazempourfard, "On the representation of Bloom's revised taxonomy in Interchange course books,"*The Journal of Teaching Language Skills*, vol. 4, no. 1, pp. 171-204, 2012.

[26] C. Munzenmaier and N. Rubin, "Bloom's Taxonomy: What's Old Is New Again. Perspectives,"*The eLearning Guild,* 2013.

[27] C. Troussas, A. Krouska and C. Sgouropoulou, "A Novel Teaching Strategy Through Adaptive Learning Activities for Computer Programming,"*IEEE TRANSACTIONS ON EDUCATION*, vol. 64, no. 2, pp. 103--109, 2020.