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Project Title	Intelligent Tutor for Python Programming
Student Name	I. K. Navaratne
Registration No. & Index No.	2013/MCS/052 13440528
Supervisor's Name	Dr. Thushani Weerasignghe

Intelligent Tutor for Python Programming

A dissertation submitted for the Degree of Master of Computer Science

I. K. Navaratne

University of Colombo School of Computing

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Declaration

The thesis is my original work and has not been submitted previously for a degree at this or any other university/institute.

To the best of my knowledge it does not contain any material published or written by another person, except as acknowledged in the text.

Student Name: I. K. Navaratne

Registration Number: 2013/MCS/052

Index Number: 13440528

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Signature: Date: 30-05-2019

This is to certify that this thesis is based on the work of

Mr./Ms.

under my supervision. The thesis has been prepared according to the format stipulated and is of acceptable standard.

Certified by:

Supervisor Name: Dr. Thushani Weerasinghe

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Signature: Date:

ABSTRACT

Since IT is an emerging field in modern world, many students try to enter to IT field. All of those students have to learn programming in this context. Teaching programming is a challenging task because it requires a lot of metacognitive skills of the student. The most effective teaching method for programming is individual tutoring. By that teacher can identify individual skill levels of the student and customize teaching methodologies according to them. But individual tutoring requires large amount of resources and impractical with higher number of students. Intelligent Tutoring Systems can be taken as an alternative solution for this. Python is one of the leading object oriented programming language picked by industry specialists and its demand is becoming high day-by-day. Although there are several ITS have been built to teach Python language, there aren't any web based system. Also they have many shortcomings such as not giving customized feedback to the student. In other hand the students in general doesn't hit the target of expectation and the volume of enrollments for such courses decrease because of not having independent learning tools for python programming as still the community is not moved to that direction like other popular programming languages. This research addresses it by designing a versatile Intelligent Tutoring System to teach Python Programming with efficient feedback mechanism.

When teaching programming, it requires giving practical exercises to the students. The ITS should have the ability to handle all answers and the feedbacks must be prepared differently. This research mainly focused on finding a method on handling feedbacks on programming solutions given by the students by using pedagogical theories. Here the solutions provided by students are checked using and run to find the correctness of the answer. Then the system provides customized feedback for the solutions after analyzing them. The subject content is divided in to several topics and system maintains and stores students' knowledge level for each topic. Using that information, system guides the student to the next exercise according to their current knowledge level.

The system was evaluated by a set of Python teachers and students. The system has been given them for several weeks to use and collected feedback on the characteristics of the system. Also it has been collected comments regarding further improvements of the system. Based on the results of the evaluation it has been concluded that the system has positive attributes to improve students' knowledge in Python programming.

ACKNOWLEDGEMENTS

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LIST OF ABBREVIATIONS

AI	Artificial Intelligence
A/L	Advanced Level
ANTLR	ANother Tool for Language Recognition
APT	ACT Programming Tutor
AST	Abstract Syntax Tree
BBN	Bayesian Belief Network
CS	Computer Science
CSS	Cascading Style Sheets
CTA	Cognitive Task Analysis
DB	Database
DBMS	Database Management System
EBNF	Extended Backus-Naur Form
e-Learning	Electronic Learning
ELM-ART	ELM Adaptive Remote Tutor
FOL	First Order Logic
GB	Giga Bytes
GHz	Giga Hertz
GUI	Graphical User Interface
GvR	Guido van Robot
HCI	Human Computer Interaction
HDD	Hard Disk Drive
HND	Higher National Diploma

ICT	Information and Communication Technology
ID	Instructional Designing
IDE	Integrated Development Environment
IDLE	Integrated Development and Learning Environment
IE	Internet Explorer
ISD	Instructional System Designing
IT	Information Technology
ITS	Intelligent Tutoring System
JDK	Java Development Kit
JS	JavaScript
KB	Knowledge Base
KC	Knowledge Component
LMS	Learning Management System
MCS	Master of Computer Science
MCQ	Multiple Choice Questions
O/L	Ordinary Level
OLM	Open Learner Model
OOP	Object Oriented Programming
ORM	Object Role Modelling
OS	Operating System
PC	Personal Computer
PHP	PHP: Hypertext Preprocessor
PITS	Python Intelligent Tutoring System
R&D	Research and Development

RAM	Random Access Memory
RUR-PLE	Rossum's Universal Robots - Python Learning Environment
SDLC	System/Software Development Life Cycle
SME	Subject Matter Expert
UCSC	University of Colombo School of Computing
UD	Universal Design
UI	User Interface
UIBR	Use Inspired Basic Research
UML	Unified Modeling Language
WBS	Work Breakdown Structure
WWW	World Wide Web
XAMPP	Cross-Platform, Apache, mySQL, PHP and Perl
ZPD	Zone of Proximal Development

CHAPTER 1 : INTRODUCTION

This chapter contains the background of the research which was conducted to develop a versatile Intelligent Tutor for Python Programming. There are sections to describe its goals, objectives and scope. Finally it includes an outline of the remaining chapters.

1.1 BACKGROUND

Since Information Technology (IT) plays an important role in every industry, number of students interested in entering IT field is very high. All those students have to study programming as a fundamental subject. Learning programming has become a challenging task to most of the students.

Students who learn programming are diverse in factors such as age, educational level, gender and economic & social background. Also they differ in metacognitive skills like planning, setting goals, initiating work, supporting future-oriented problem solving activities, monitoring and managing progress on tasks to detect and correct errors, and keeping track of the effect of one's behavior on others [1]. Metacognitive skills are very important in programming because programming requires higher order thinking. In classroom learning also it is extremely difficult to create a single lesson to suite all the students with above diversities. One-to-one tutoring is suitable to overcome this problem. With one-to-one tutoring tutor can create a study plan according to the students' ability and to strengthen the weak areas of the student. Bloom [2] reports that student achievements in classroom instruction (1:30 teacher/student ratio) was differ from one-to-one tutoring (1:1 teacher/student ratio). (Figure 1.1) But one-to-one tutoring is impossible to achieve practically without technology since it is time and resource consuming.

In modern world students are tend to study in different learning approaches rather than using the traditional classroom-based learning approach. Because the technology has developed to a stage where students are able to build their learning environments in their preferred venues and time durations. Teaching and learning culture has changed to teacher-centric to student-centric during the past couple of decades.

Learning Management System (LMS) is used to offer learning content organized in courses to an audience in an Electronic Learning (e-Learning) platform. Usually most LMS are web based applications [4], so the learner will get the freedom of accessing the tool wherever and

whenever they wish. According to the updated rankings in 2018, following key features are included in most of those web based tools. They focus on educational courses which can be created, administrated, and controlled using a web program. Learners are evaluated and grades/reports can be generated. But LMS is bit short when providing some level of instant analyzed personalized feedback for the learners when they get assessed. Even feedback options are available in those web based LMS tools, it need some manual involvement of subject teacher and more time consuming when providing the appropriate feedback. Internet has become a popular medium of providing course content as online so individual learners can access the content on demand.
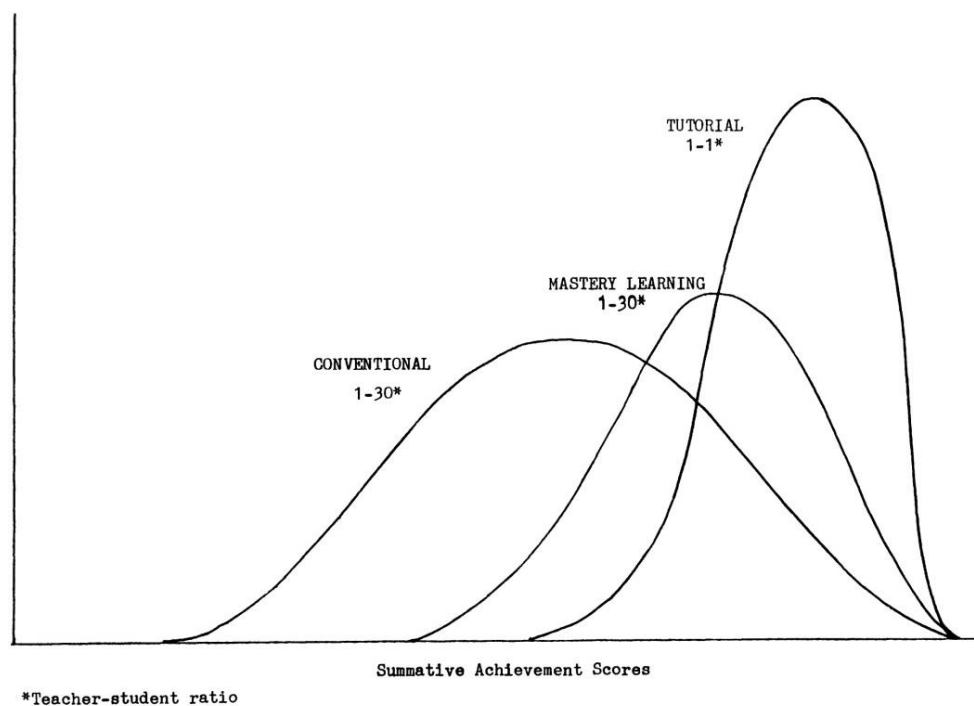
Figure 1.1: Achievement distribution for students under conventional, mastery learning and tutorial instruction. [Bloom 1984]

Using an Intelligent Tutoring System (ITS) is a better solution for this context. ITS is a branch of Artificial Intelligence (AI) which forms computerized systems that offers one-to-one tutoring; provide customized and immediate feedback according to the student activities, without an involvement of a human teacher. Also AI branches such as knowledge representation, Search and Logical AI can be used in this research. ITS can be considered as a branch of new education paradigm which is added on top existing LMS architecture. It enhanced the culture of LMS assessment mechanism more dynamic. Feedback facility changed as an essential component in online educational systems which make the learning

environment more effective. Providing continuous feedback throughout an online course is compulsory because that make the learners' experience more informative, engaging and it helps to keep the encouragement and motivation of the learner until to the end.

ESOFT Metro College – Battaramulla Branch has been selected as the client of the project. Courses offered by the institute varies from government national level examinations such as Information and Communication Technology (ICT) subject for both Ordinary Level (O/L) and Advanced Level (A/L) students, Diploma/Higher Diploma courses, both Local/Foreign affiliated Degrees and etc. When considering course contents Python programming language is one of the most common options among those various courses teach in the institute. And also the number of students pick those courses over the years has been increased into a greater extent.

Python is widely used programming language that helps to integrate computer programs more effectively. It is a high level, dynamic programming language. Most of the Computer Science (CS) courses include Python in their curriculum. The number of students who has the necessity of learning Python is high. According to the survey results published by Tiobe Index, PYPL Rankings and Google Trends in late 2018, Python claim one spot among top 3 positions on those rankings. Subject to literature, Java and C will share the most popularity alone with Python. It shows how demanding Python programming language in the society and need of an ITS for such a popular language in the industry [5]. Statistics prove the demand in the industry for the Python developers and the volume of students willing to follow Python programming related courses also increase day-by-day [5]. So it has been decided to research on devising a versatile intelligent tutor for help students learning python.

The World Wide Web (WWW) has the world's largest collection of educational materials. It contains materials in different media such as text, graphics, audio, and video. WWW supports applications like email, ftp, conferencing…etc. Because of WWWs' popularity, almost all students are interested in learning using it. According to latest statistics of 2018 more than 4 billion people connect to the internet and it has the growth percentage of 1066% from 2000 to 2018 [3]. These statics are still growing astronomically. Below Table 1 shows the increasing percentages of Internet users with respect to world regions.

Goldstein [6] reports Web-based teaching and intelligent tutoring systems are an excellent marriage of two advanced technologies. By developing a Web-based ITS we can takes advantages of both those technologies and the system will be accessible to a wide range of students.

Table 1 : World Internet Usage & Population Statistics [3]

WORLD INTERNET USAGE POPULATION STATISTICS JUNE 30, 2018 – Update						
World Regions	Population (2018 Est.)	Population % of World	Internet Users 30 June 2018	Penetration (% population)	Growth 2000 - 2018	Users % of Table
Africa	1,287,914,329	16.9%	464,923,169	36.1%	10,199%	11.0%
Asia	4,207,588,157	55.1%	2,062,197,366	49.0%	1,704%	49.0%
Europe	827,650,849	10.0%	705,064,923	85.2%	570%	16.8%
Latin America / Caribbean	652,047,996	8.5%	438,248,446	67.2%	2,325%	10.4%
Middle East	254,438,981	3.3%	164,037,259	64.5%	4,894%	3.9%
North America	363,844,662	4.8%	345,660,847	95.0%	219%	8.2%
Oceania / Australia	41,273,454	0.6%	28,439,277	68.9%	273%	0.7%
WORLD TOTAL	7,634,758,428	100.0%	4,208,571,287	55.1%	1,066%	100.0%

1.2 MOTIVATION FOR THE PROJECT

Research in Intelligent Tutoring Systems has been growing within last several decades. Many ITSs have been developed for different subject domains. There are ITSs to tutor programing languages such as Java, C, Pascal, Python, Prolog, PHP, and etc. But very few are used in practically. Some presents lessons in the same way to every student. Some doesn't personalize instructions according to the student's ability and weaker areas.

The students are very diverse. The students have different learning skills and their experience in programming in other languages can differ from novice to expert. Some may have experience console applications, windows applications or web applications. That experience may cause difficulties or easiness in programming with python.

A versatile ITS should have the ability of handling these circumstances. Also ITS should be capable of analysing the programme code written by each student. Same programme code can be written in different ways. ITS should accept alternative solutions for each programming code module. It has identified that Intelligent Tutoring Systems need significant improvement to overcome above problems.

Following Table 2 shows increasing demand of python among the community according to the figures which is gathered by two leading survey conducting bodies in September 2018. So that makes primary factor of selecting Python as the language to cater under the proposed ITS.

Table 2 : Programming Language Demand Statistics in September 2018 [5]

Tiobe Ranking	Change YoY	PYPL Ranking	Change YoY
Java	+4.75%	Python	+5.7%
C	+8.06%	Java	-0.6%
Python	+4.67%	JavaScript	+0.0%
C++	+1.83%	PHP	-1.4%
Visual Basic .NET	+3.33%	C#	-0.4%
C#	-1.48%	C/C++	-0.8%
PHP	+0.57%	R	-0.2%
JavaScript	+0.11%	Objective-C	-0.9%
SQL	+2.06%	Swift	-0.9%
Objective-C	+0.00%	Mat lab	-0.4%

Giving personalize feedback during the session will be another challenging aspect. Because those feedback must be student and problem specific. There are plenty of research going on the feedback preparation and delivering but still there are no standardise approach of achieving the expected quality of feedback. Even there are some existing strategies of providing feedback, but no universally accepted framework for feedback handling. That

makes me motivated studying about the best strategy of providing a reasonable feedback on top of the ITS platform which is planning to develop.

Apart from that there are lots of pedagogical practices used in the manual teaching process which are required to be supported by ITS too. One key area is collaborative learning though peer learning. It encourages learning via group activities in a knowledge sharing manner with the other colleagues learning in the same domain. Even LMS support this nature of facility yet there are no ITS support for that. Underneath research is focus on about studying best possible way of blending those pedagogical theories to enhance the learning experience of individual learners.

Finally there are no methods developed for rewarding students by measuring their knowledge level. So that also increase my hunger of building suitable mechanism to reward learners based on their achievements while capturing the knowledge level of individual candidate using ITS. Regardless of the ways that they accomplish the task under ITS their evaluation is done using a common set of criteria and the analysis will be done based on the stored data related to learner activities.

Study on those drawbacks, motivated for this research to develop an Intelligent Tutor with the capability of personalizing the lesson process and instructions given to the student and, and presents a process of analysing programme code to accept alternative solutions to a programme code module. It won't say that the human teacher role will be totally escape from the scenario but proposed solution need find a better way of mixing those tools and techniques which teachers use during classroom sessions. Those factors make me motivated to conduct a weighty research which can be valuable to the field of education.

1.3   OBJECTIVES OF THE PROJECT

This research has been conducted to develop a versatile Intelligent Tutor for python programming which gives personalized feedback for students. There are many ways to provide feedback in Intelligent Tutoring Systems. It has to be considered in the way of generating correct feedback and the way of presenting that to the student. Since programming is a subject that needs higher order thinking skills, the Intelligent Tutor should use creative programming lessons to facilitate the learning of the student. So the main objectives include defining a method to identify the current knowledge of the student and categorize him in the beginning of the learning process, lessons and exercises have to start according to the level of

the student. Then the system must be capable of capturing student level dynamically [7]. System has to select and suggest suitable exercises based on the current knowledge level of the student.

Another challenging objective is identifying alternative solutions for a single programming exercise. For example, an answer for a question requires generating the grade according to the marks obtained can be written in many forms. It can be written using series of *if* statements or *elif* statement. Also a solution that needs a looping structure can be written using *for* loop or *while* loop. Conditions for those selections and loops can be written in many forms. So there should be a mechanism to identify this huge number of solutions to the exercises. Students' solutions have to be analysed for correctness according to that mechanism and provide feedback based on the result. Providing a feedback with reasoning will be another objective of the system.

Maintaining a proper flow and interaction with the students, providing a personalize feedback after analysing the students' performance will be some key objectives of the proposed Intelligent Tutor. This requires studying on how students engage with the traditional method of studying similar course in such institutions and to remodel the architecture in an automated platform where everyone will use it for leaning python programming with minimal intervention from the lecturer.

1.4 REARCH QUESTIONS

The main objective of this research is find an appropriate method to provide personalize feedback to the students learning python language. The present research aims to achieve this objective by answering the following set of research questions.

1. **How to construct the most appropriate feedback related to students' activities in Intelligent Tutoring System?**

2. **What is the most efficient way of presenting the constructed feedback to maximise learning experience of students?**

3. **What is the best method to measure the student's knowledge level?**

1.5 SCOPE OF THE PROJECT

Scope of this project is to build an Intelligent Tutor which can learn about the students and assist their learning process on python programming language. System will be capable on adjusting the tutoring process based on the continuous feedback that it gives to the student during training. It will be the most appropriate feedback designed and presented in the most suitable manner so that the student will be able to grab the real value of the feedback without additional effort.

The students will be categorized according to their abilities and competency levels. A diagnostic test at the beginning will assign the students (users) to relevant levels. The knowledge need for user profiling will be gathered by conducting learner analysis. Cognitive Task Analysis will be conducted to get an understanding about the tasks that need cognitive activities. Literature emphasis that before student being tested against different areas of subject content allowing them to practice using sample assessment is important to uplift their rate of getting better results than testing them upfront. So students will be educated with the necessary subject area before being tested will be used as a good pedagogical learning approach.

Bringing all the visual experience that students experience during classroom sessions is vital then they able to visualize the same practical experience like they do in the traditional environment in a digital space. Corporative learning like group activities enable students to mix their skills so it will promote the better collaborative learning using ITS. Each student abilities can be blend to produce productive and interactive learning. Awarding students during their achievements will be a best practice so it leads to keep the students motivated and encouraged during their study time.

The knowledge base will consist of knowledge about instructional domain (python language), knowledge about the student and knowledge about relevant pedagogical approaches (tutoring actions & strategies). Also the tool will have communicational knowledge (how to present information via the computer output) that needs to present the information in the most suitable form for the student to understand. So the system will be sound enough to cater for all levels of students with personalize assistance and feedback.

Developing an ITS is very challenging and time consuming task. The reason for that is a new Knowledge Base (KB) should be specifically built according to the subject. The proposed Intelligent Tutor will have knowledge in following areas.

- **Syntaxes in python language and procedures to solve a problem.**

    It has been decided to develop the tutor for G. C. E .O/L syllabus. So the system will cover syntaxes of python language which are related to G. C. E .O/L ICT syllabus. For a given problem there will be more than one method of providing a solution, in the same way different students will have different strategies to tackle a given problem. System will check against all sorts of errors and identify the weak areas of student and propose exercises to improve those subject areas.

- **Students' characteristics related to learning Python.**

    To interact with the student, the system should have a good knowledge about the student. Even though students' characteristics like age, gender, emotions…etc., are important in this context, the proposed tutor will consider only about the characteristics related to learning.

- **Relevant pedagogical approaches.**

    Tutoring methods and strategies need to assist students in different levels will be included in the KB.

- **Communicational knowledge need to represent lessons to the student.**

    Knowledge that needs to present the information in the most suitable form for the student to understand comes under this category.

1.6 DELIMITATIONS

As mentioned in the above section developing an ITS is very challenging and time consuming task due to the complexity of the KB. Because of those constraints it was decided to exclude the below set of subject content, functionalities and the concepts from the implemented system.

First if we look at the subject content include the areas such as complex data structures like lists, tuples and dictionaries based data manipulation, python functions, object oriented programming in python and etc. Based on the time constraints it was not planned to cover those advanced python subject area in this development.

To handle logical errors made by the students using the system, there are no currently implemented tool/support on this context. So spending time to focus on developing such kind of a module or tool will lose the primary focus of this research project of providing

personalize feedback to each students during activities. So it was decided to cover the logical error handling as future enhancements, while the project continues with the agreed scope.

Finally, statistical data analysis tools will not be used to collect and analyse data which are gathered during student activities, rather all decisions and comparisons are done in a method like what teachers usually do in a normal classrooms. Because the decisions made by human teachers with their level of experience is so vital to take suitable decisions. And also the effort which required putting to prepare data according to the supported format by those statistical data analysis tool require some prior knowledge and experience on them.

1.7 RESEARCH APPROACH

This section covers the research approach/methodology which is going to use during this research project. It was decided to use the Use Inspired and Applied approach, and full details left behind selecting the appropriate research approach to carry forward this research are duly discussed as a part of the Research Methodology chapter.

1.8 STRUCTURE OF THE THESIS

This section outlines the remaining chapters of the document. Chapters are categories as Background, Analysis & Designing, Implementation, Evaluation and Conclusion. Appropriate references are included to link the content with the sources which is used to gather relevant information. Additional materials are included as Appendixes to maintain the separation of spare essentials with the main content. Short descriptions on each of them are given below to provide a prior understanding to the reader.

Background

This section includes the background study of the research conducted. Review of the literature that is relevant to this research, research methodologies used in it, research questions, similar systems analysis, drawbacks of those systems, new features that need to be introduced to make ITS more effective are described in this chapter.

Research Methodology

This chapter contains the analysis conducted within the project. Gathered requirement and identified constraints are also described as a part of this chapter. Detailed description and

results of learner analysis that conducted to gather knowledge required to categorize users included in this section. Furthermore, research design methodologies and development methods used, reasons for selecting such methodology are described. How research questions are going to address, evaluating the sustainability of the selected research methodology are covered in this chapter. Step by step approach how research is conducted is also included as a part of this chapter. Artificial Intelligence (AI) concepts, Knowledge Base structure, concepts in language parsing, program analysis process, alternative solution selection, lesson selection, solving exercises, methods of generating and presenting feedback are described in details within this chapter. In addition to that as a part of this chapter, resource requirements are classified and addressed as hardware and software requirements.

Implementation

This section includes all the details about development & implementation details of the Intelligent Tutor and contains user interfaces and the way which system communicates with the user interfaces. Part of core system module coding and KB structure is also explained in this chapter. It explains the process of achieving solutions to the identified research questions.

Evaluation

This chapter discusses about how the Intelligent Tutor was evaluated and tested. Test plans, test cases, how the testing is conducted, results & feedback of testing and discussions about results are included. It also covers the evaluation technique which is used for the purpose of conducting evaluation and some sample comparisons are include as graphs as an evidence. It helps to visualize the achievement of research outcome and it justify the true output of research being conducted.

Conclusion

This section describes about results of this research, lessons learnt and the implications for future work. It is done as a part of the post own work criticism to see whether real objectives are met or not during project. Accordingly, discuss about new features introduced, problems encountered within the research and the solutions taken to get through those problem are critically addressed as a part of this section.

The rest of the document includes a set of Appendices that supports the explanation provided through the document.

CHAPTER 2 : BACKGROUND

This chapter describes in detail about the background study on existing literature related to the research. Similar systems relate to Python ITS are thoroughly compared in the following section. Factors which inline to the research and the path to obtain answers to the stated research questions are discussed as a part of this section.

2.1   LITERATURE REVIEW

2.1.1   DIFFICULTIES IN LEARNING PROGRAMMING

It has identified that lots of students have problems in learning programming. Large number of drop outs occurs in many CS programs because of the programming problems. Truong et al. [7] reports 35% of first year IT students at the Queensland University of Technology, failed their programming course. Investigating and identifying the reasons for that difficulty is important when developing an Intelligent Tutor.

Mow [8] reports five main areas of difficulties in learning programming.

- **Cognitive Requirements of Programming**
  Programming is a cognitive task. Student should have cognitive abilities like perception, attention, memory, motor skills, visual & spatial processing… etc., to learn programing. Student has to hold wide range of information in his memory. Also need to understand programming concepts and build the solution conceptually before converting them to program code. Designing skills and creative thinking should have to model and design solutions. So the entire programming process requires many cognitive skills. Students have to enhance their cognitive skills to make their learning process successful.

- **Syntax & Semantics**
  As the first step in programming, students have to learn symbols and notations of the programming language. Then syntactical rules must be used to combine those notations into a program. Students find difficulties in selecting correct syntaxes and semantics to construct a program. The areas that students make more mistakes are loops, conditions, arrays and Object Oriented Programming (OOP) concepts etc. Another issue is programming languages use words similar to English language but gives a different meaning within the program [9]. Leaner can confuse on them and face difficulties in developing a program.

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There are Integrated Development Environments to support students with keywords and syntaxes but when considering about Python, lack of having Python IDEs, makes a big challenge on providing support for novice learner. Even though there are some basic level of open source IDE support available, but most of them are windows based solutions which cannot be integrated directly with an ITS. So learning it from the starch is bit difficult. PyCham is available as an IDE but the full version is commercial.

- **Orientation**

Students have the idea of "programming is a difficult subject". Similarly most of the students try to get through the exam by memorizing notes and textbooks without practically learning the programming language. Those incongruous, incorrect attitudes and practices make programming a difficult subject.

- **Auxiliary Skills**

A good programmer needs to have auxiliary skills like logical reasoning, problem solving, planning…etc. Lack of these skills increases basic errors of programs that cause due to poor planning. Students have to develop auxiliary skill while learning programming to ensure quality of their programs.

- **Resource Constrains**

Structure of the course can make difficulties in learning programming. Since students are from diverse backgrounds and with different levels of skills, same course may not be suitable for each. Limited time constrain does a huge impact in the learning process. Most courses spend large amount of the time to explain the syntaxes and concepts, leaving very little time to develop relevant skills that need to plan and write effective programs.

Also Mow [8] proposes solutions for the above five main areas of difficulties in learning & teaching programming are discussed in Table 3.

Table 3 : Programming Issues & Possible Instructional Solutions

Issues In teaching programming	Potential instructional solutions
Cognitive Requirements of Programming	Visualization (debugger) , Unified Modeling Language (UML) Modeling, Coaching , Modeling, Scaffolding Reflection, Articulation

Syntax and Semantics (Notation)	Situated Learning , Scaffolding Multiple examples , Modeling Reflection , Articulation Coaching in the use of secondary notation
Orientation	Situated learning Good introductory section on basics Programming concepts
Auxiliary Skills	Coaching in file management compiling debugging
Resource Constraints	Construction of a reader Online notes

Any solution that proposes to teach programming should overcome above problems to make the learning process effective.

2.1.2 APPROACHES TO OVERCOME DIFFICULTIES IN LEARNING

Researchers have defined several methodologies through the huge amount of researches done to find solution to problems in learning & teaching programing. Following are several classifications of potential approaches to those problems.

Mow [8] classification

1. **Pedagogical Solutions**: focus on using different teaching strategies to maximize learning.
2. **Technological Solutions**: focus on using computer technology to create effective learning environment.
3. **Content-based Solutions**: focus on using different types of content knowledge required by the student in order to facilitate learning.

Miliszewska & Tan [10] classification explains four pedagogical techniques.

1. **Analogy**: refers to the use of illustrative example of concepts that student have seen before.
2. **Relevance**: refers to showing students a purpose of what they are learning.
3. **Continuous Reinforcement of concepts**: refers to repeatedly reminding the student of what they have learnt.
4. **Use of Technology**: refers to the use of computer technology to support learning.

By looking at these two approaches we can see that Technology plays an important role on them. That means computer based learning systems are good solution to overcome problems

in learning programming. There are many computerized learning systems for programming (web based and windows based applications) but they presents same set of lessons and exercises to all students with different skills, same as in the classroom teaching. Then students participate in those online sessions won't feel any significant difference between their natural classroom environment and the digitized pace. When learning using computerized system, students expects to learn based on their own style. Learning needs are differ from student to student. To get a better outcome, computerized learning system should have the capability of catering each student individually while analyzing their individual abilities and inabilities. ITS can select as the best solution for this dilemma.

2.1.3 INTELLIGENT TUTORING SYSTEMS

Intelligent Tutoring Systems are computer based tutoring systems which interact with individual students according to the individual requirements. They personalize the tutoring process according to the student's skills. The field of these systems is grounded in three disciplines: Computer Science, Psychology and Education [11]. Figure 2.1 shows those three disciplines.
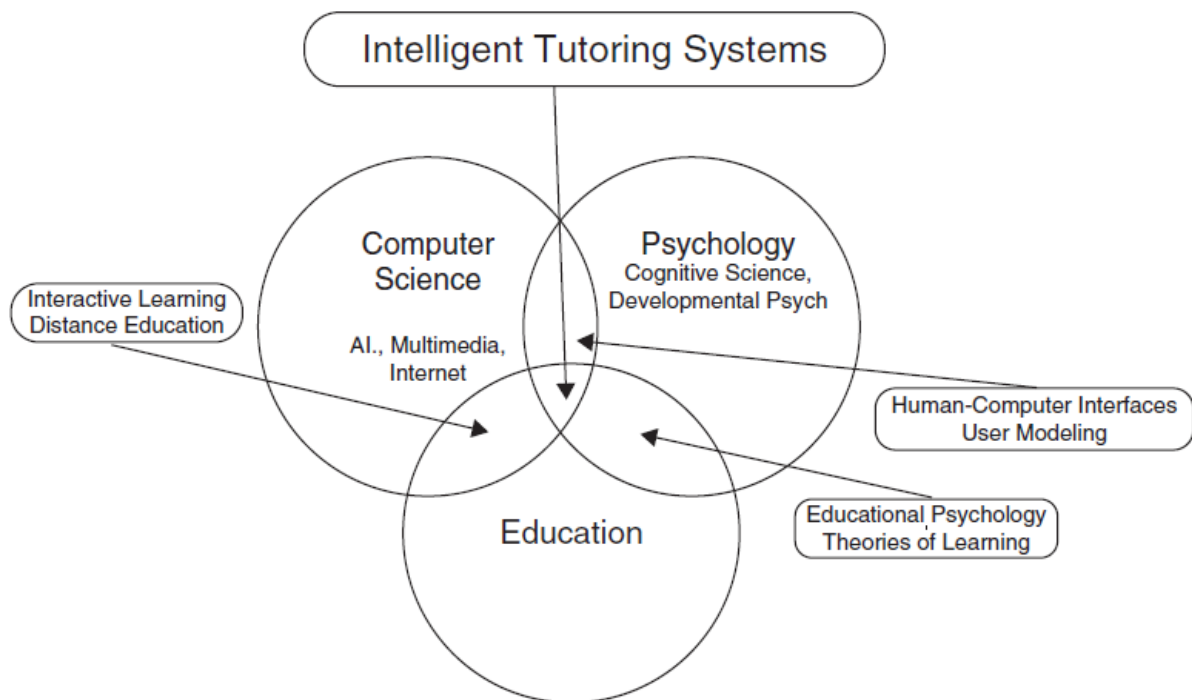
Figure 2.1: The field of Intelligent Tutoring Systems is grounded in three disciplines Computer Science, Psychology and Education

2.1.4 ARCHITECTURE OF INTELLIGENT TUTORING SYSTEMS

Intelligent Tutoring System should have several modules to function properly. There are many models to express those modules. One popular classification [11] is shown in Figure 2.2.
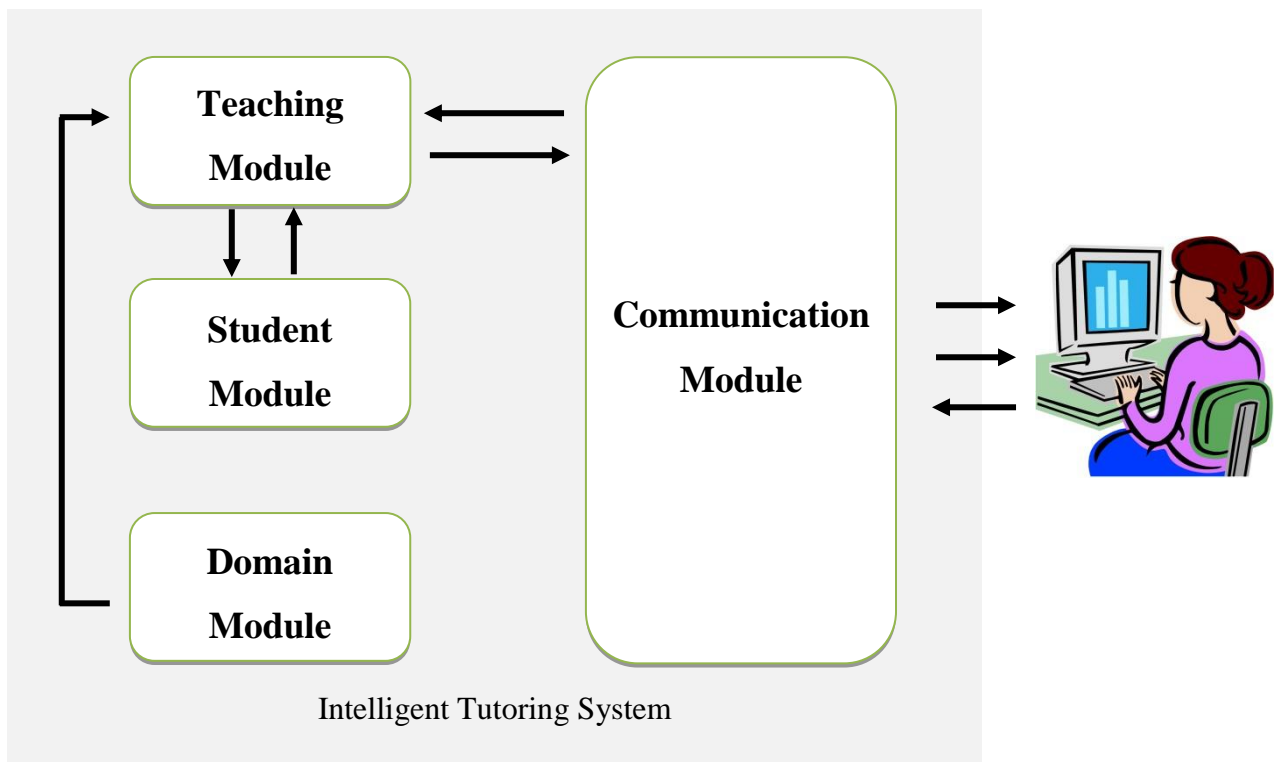
Figure 2.2: Main Modules of an Intelligent Tutoring System

Communication module handles all interactions with the student. It presents lessons and exercises to solve. Student enters the solution to the ITS via communication module. Teaching module analyses the solution using the information obtained from student module and domain module. Domain module contains details about subject taught by the ITS. That knowledge can be used to check the correctness of the solution. Student module contains information about the current status of the student. Teaching module uses that information to generate feedback for the student. That feedback is presented to the student using communication module. Then the system generates an opinion about the students' knowledge using the correctness of the given answer. That opinion is updated to the student module to maintain the current status. This basic model is commonly used in most ITSs.

Following is another model presented by Pillay [12]. It is an extension of the above architecture with 10 modules as shown in Figure 2.3. Since this architecture is specific to teach programming, some modules are included in order to make it common to all programming tutors.

The interface module of this architecture is similar to the communication module of the above architecture. The domain module of figure 2.2 is a combination of domain module, problems module, expert module and code specification module in Figure 2.3.
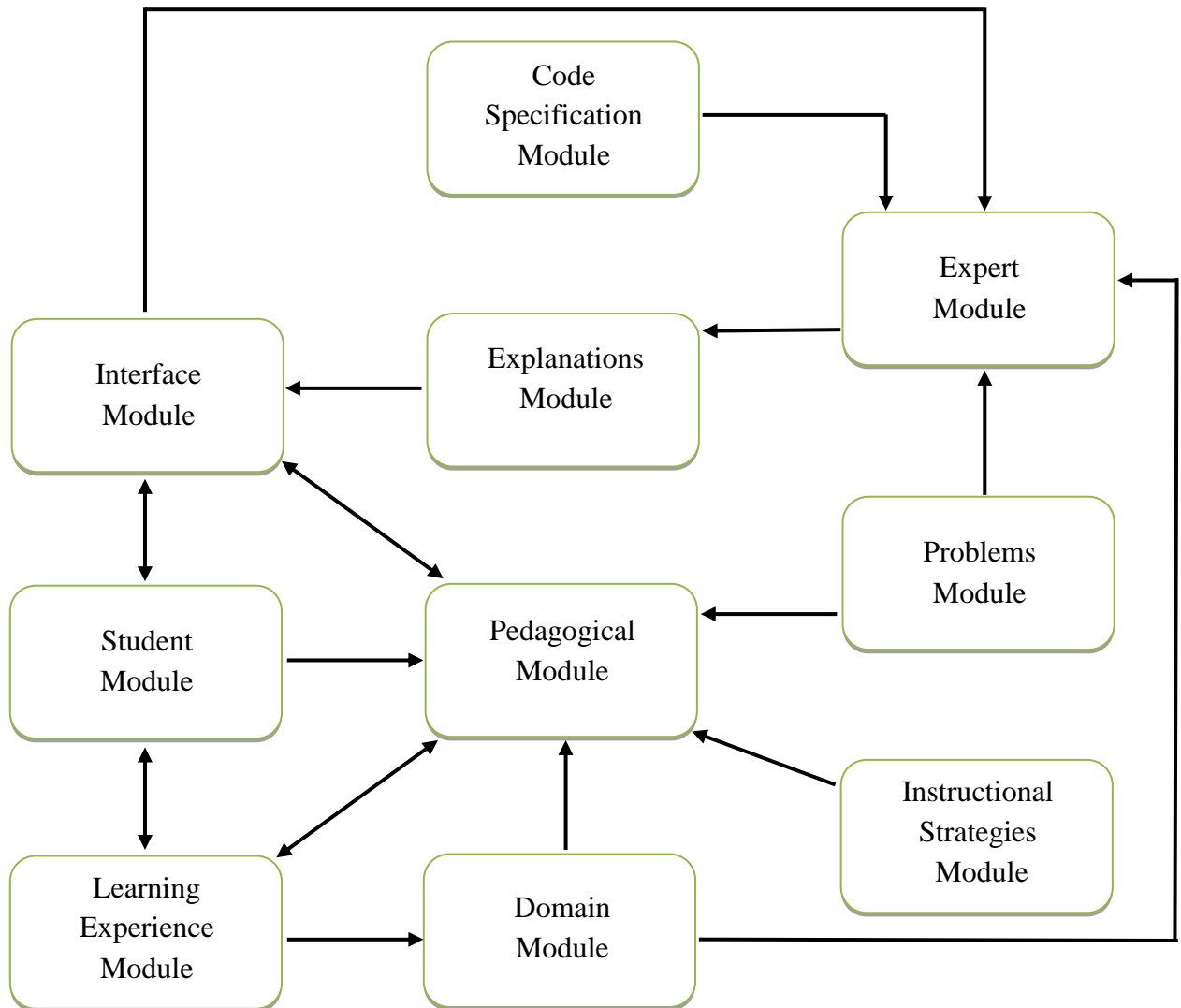
Figure 2.3: Generic Architecture for ITS to Teach Programming

- **Domain Module**: Subject content is stored in this
- **Problem Module**: Contains the actual problems used to teach programming skills
- **Expert Module**: Analyses students' solutions to problems
- **Code Specification Module**: Stores algorithms to problems in a language independent manner.

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Combination of pedagogical module, explanation module and instructional strategies module is corresponds to teaching module of Figure 2.2.

- **Pedagogical Module & Instructional Strategies Module**: Contains the approaches need for teaching.
- **Explanation Module**: Responsible for generating explanations for the students' answers and errors.
- **Learning / Experience Module**: Improves the performance of tutor by learning from students actions.

Following areas cover a detailed description about the main modules of an Intelligent Tutoring System.

2.1.4.1 THE DOMAIN MODULE

The domain module is an key component of an ITS since it contains knowledge relevant to the subject that is taught by the system. Other modules are developed around the domain module. Programming is a practical subject. So just providing lessons and exercises to the student is not sufficient for a good tutoring. Proper feedback and exercise suggestions are important in increasing programming knowledge of the student. Feedbacks must be organized in the way of generating correct feedback and the way of presenting that to the student. When providing feedback some level of data mining techniques have to be used. Good program analyzing mechanism should be used to generate a proper feedback. Following are some analyzing methods use in ITSs.

- **Static Analysis**
    Program code is evaluated against programming standards, Syntaxes & Semantics. Code is not executed within this process. The disadvantage is that this can be used of small specific set of solutions. Static analysis is not suitable to check programs which have many ways to obtain the output.
- **Dynamic Analysis**
    In this analysis program is executed using test data to check whether the output is correct. Program code is identified as correct on condition that the output is correct. This is suitable for analyzing alternative solutions. This analysis cannot take as

successful since inappropriate program segment also can provide the correct output. Also output can depend on the selected input. A program segment that gives correct solution for a one input can give wrong result for another input. So this method does not guarantee the total correctness of the solution.

- **Combination of Static & Dynamic Analysis**

    Static & dynamic analyses are combined here to overcome weaknesses of both. This method is beneficial in selecting alternative solutions but it is limited to a specific programming language.

2.1.4.2   THE TEACHING MODULE

This module includes the methods that need to provide better leaning through the ITS. This is an important module that applies theories of cognitive science and education to enhance the learning process. This section describes about some teaching aspects concentrates by the teaching module.

Feedback to the Student

After analyzing the students' solution it is essential to give appropriate feedback. Many systems use different types of feedbacks and different methods to assist students in learning.

In many systems, to get a feedback student need to make an error in an answer or reach an impasse and need to ask for a help. During such event the tutor can indicate the error (verification) or give a detailed description about the error (elaboration) [13]. Both these methods are used in many tutor but studies have shown that elaboration provides better learning than simple verification [14].

Timeliness of feedback is also very important. Tutor must provide the proper feedback when a student makes an error. Proper feedback at correct time is known as *proactive feedback*. Sometimes too much assistance can be a burden to learning. Proactive feedback does not allow students to realize that they have reached impasse. At that time *on-request feedback* is better to use. It has proven beneficial because students determine that they need help accept the assistance amenably.

Zone of Proximal Development (ZPD) is an important theory in education related to the level of feedback. It refers to the range of tasks that are too difficult for an individual student with his current level of knowledge, but can mastered with the assistance of a skilled person. ZPD

of each individual student is different. Presenting the same error message or feedback to each student is not beneficial. Many systems use multilevel feedback approach. ZPD can use to give the appropriate guidance to the student to get the most suitable level of feedback based on their knowledge level.

Selection of the next problem

Many systems offer exercises to students according to a predefined order. Some other gives the chance of selecting questions to the student. Both these systems are not suitable because the next selected question does not depend on the students' knowledge level and abilities. The ZPD concept can be used to overcome this problem and provide exercises according to the students' level. In this subject matter is broken in to Knowledge Components (KC). Programming exercises are maintained for each KC. The most suitable exercise is selected considering the problem with least number of unknown KCs for the student. The best exercise can be selected in this manner.

Another method is mastery learning [15], [16]. This provides student more and more exercises to master the same KC. Then it selects the best exercise in the above method.

2.1.4.3   THE STUDENT MODULE

This is also an important component, since it needs to individualize instructions. Students are human beings who have diverse abilities, thoughts, attitudes, learning styles and knowledge levels. In this system only the characteristics related to learning are considered.

Knowledge level related to given domain is difficult to measure. KC concept is suitable for this. Subject topics and cognitive skills are broken down in to several components and knowledge level for each KC is considered instead of whole subject domain. When measuring the knowledge level of a KC, the first thing is to know whether the KC is known or not known by the student. But it is difficult in sometimes student can make a mistake or get the correct answer by luck. So there is an uncertainty when measuring the knowledge level of KC [11]. It should be maintained as a probability. There are many methods of student modelling.

Bayesian Belief Networks (BBN) is a very often used method to model the knowledge of students. After interacting with the student, this method uses a set of equations to calculate the current knowledge of the student. It consider about the students' previous knowledge of the KC and the response during the interaction to calculate the current knowledge. Some models

based on BBN assume each KC is independent from each other. But it is not real practically. KCs are dependent on each other in a pre-defined order. Ex: Student should have knowledge about sequential statements before he proceed to selection statements. Reye [17] proposed a method of modelling this relationship between KCs. It produces an accurate measure of students' knowledge on KCs.

Open Learner Model (OLM) gives the student the opportunity to view the student model and metacognitive tips. It gives the benefit of finding out the systems' judge about the student. OLMs are in three types.

Inspectable: Allows the student to view the systems idea of his knowledge but doesn't give permission to alter it.

Editable: Gives opportunity view and edit their knowledge level.

Negotiable: This allows the student to negotiate his knowledge with the system providing a dialogue.

Some students prefer to have overview and a detailed view. OLM model has the ability to maintain several views such as internal & external views. External view is in understandable format to the user. Student has a choice of selecting the view that they want to see. OLM is a preferred feature for ITSs.

2.1.5   PEDAGOGICAL THEORIES

Pedagogical theories are some best teaching practices which can be used in classroom environments by subject teachers to provide the best effective way of learning experience for the learners. It is combined with the effective teaching approaches with the modern technology available in the world for teaching. Most of the theories are reformulated with the enhanced technologies available in the industry and are aimed to provide sustainable education curve for all levels of students with mixing levels of abilities by those individuals. Following are some of the top rated pedagogical practices which we can use in educational system. Some of them are Visualization, Cooperative Learning, Inquiry-based Instruction, Differentiation, Behavior Management, Professional Development, Providing Ongoing Feedback and etc.

Visualization: Making all of the academic concepts available in visual and practical form so the learners feel the same comfort as they study in actual classroom environment. As an example displaying photos similar to class environment and activities can be considered.

Cooperative Learning: This method encourage students to work in a collaborative nature while mixing their individual abilities. If focus on allowing learners to perform activities in small pre organized groups or as a whole class. So individual can contribute to a success result as a team. Asking for help from peers will be an example for this theory.

Inquiry-based Instruction: Allowing students to ask questions and clarify their doubts helps to gain a deeper understanding and helps them to overcome the problems that they face during studying. It will be more useful for problem solving as well as for investigating their own ideas. As an example they can share what they achieved for an activity or simply they can ask some opinion from others on about a specific thing.

Differentiation: Giving customized activities based on students abilities will be an effective method so no one will be dropped from the learning curve. Everyone will be catered based on their needs than providing equal context for all. It helps to cater the individuals on demand.

Behavior Management: Based on the student performance rewarding them will be highly valuable technique. So each will get motivated to compete each other resulting more opportunities for each student to gain the desired outcome from the learning. Prizes can be awarded after evaluating their task achievement during activities to the best performing students. In addition to that students can be moved up and down in the rankings so everyone will try their best to catch up even they perform low for a specific section. Those concepts will be directly support to behavior management of the individual learners.

Professional Development: As each student is unique and differ from each other teachers have to use wide range of strategies to cater for those different students. Various teaching styles and capabilities must be mixed to provide successful education platform for the learners. Making dynamic and motivational work environment helps to develop student skills. This tells teacher must combine the best effective teaching styles which will be required for professional development.

Giving Ongoing Feedback: Feedback will be an essential component in both offline and well as online learning environments. Feedback will be useful to create the learning experience of students informative, engaging and motivational. Because the feedback which the student get for specific activity will be useful to provide some extra level of information which is associative to the situation. So the learner will get motivated and try to come up with better results in the future activities. Feedback must be specific and relate to the given situation or learner action. Apart from that peer feedback will be another important concept which can be gained though collaborative group activities.

2.1.6   ITS VS E-LEARNING

In general ITS closely work with the learners' psychological state as well as their current knowledge to provide personalize instructions and feedback when they take activities during learning time. To become successful in nature ITS must acts same as a human teacher so the learner feel no artificial behavior about the system that they use for study programming.

WWW and related technologies makes the learning on top of online nature so the same classroom activities are automated on those platforms. Moodle, Blackboard, iSpring, ATutor are top rated e-Learning authoring tools available in the industry. They mainly consider the qualitative factors of presentable materials and the learning content while using rich multimedia content. But they mainly work without controlled evaluation mechanisms.

Both ITS and e-Learning solutions provide tutorial service and are activity based, but the main difference between ITS and e-Learning solution is they work on different disciplines. In

e-Learning platforms activities are evaluated mainly by a human teacher whereas in ITS student performance is evaluated and monitored by an intelligent agent (basically a computer based software system). The main focus on ITSs for programming paradigm is to provide the learner to code and execute the activity solutions in online environment and to get instance feedback on about their work. And also ITS focus more on problem solving during learning. Another major difference is how they provide feedback and the time pace of those feedback returning to the learners. So it focus more on controlled evaluating procedure of different level of learners.

So the bottom line will be ITS are more responsive and dynamic when handling student feedback than an e-Learning solution. Special when learning programming related courses ITS play far more active role than e-Learning platform.

Apart from the above factors following Table 4 compares some major differences in ITS and e-Learning.

Table 4 : Comparison of ITSs Vs e-Learning Systems

e-Learning Systems	Intelligent Tutoring Systems
Organizing learning & Presenting materials	Aiming at improved learning
Massive content	Restricted content
Content crafted by normal authors	Carefully crafted content
Potentially collaborative authoring	Single author/designer
Several ontologies, content-based	Fix abstract domain ontology
Simple feedback	Elaborate feedback
Pre-scripted feedback	Some feedback generated
Service approach	Tightly integrated components
Scalability and reuse important	Few generalizable solutions

2.1.7 COMPARISON OF EXISTINGITSS

This section describes and compares about features of existing similar ITSs. There are some ITSs developed for teaching other subject areas like mathematics, statistics, physics, medical science, computer hardware and so forth other than programming. Several ITSs which developed to teach programming are only selected for comparison. As the primary research is

focused on developing an ITS for Python programming language, programming language(s) supported by each solution and feedback mechanism is compared.

C-Tutor

C-Tutor [19] is developed to learn C language. In this programs are converted in to canonical format and analyses using intention based analysis. Selects exercises according to the current knowledge of the student. C-Tutor presents feedback on request of the student. Providing feedback on request will be major concern in C-Tutor as in this scenario students may not get the necessary support as if they did not request the feedback by mistake.

ACT Programming Tutor

ACT Programming Tutor (APT) [18] is a tutor which has developed to learn short program writing in LISP, Prolog, and Pascal. This compares solutions against a set of production rules. It gives immediate feedback to students with three levels of hints. Also uses inspectable OLM model. At the end of each section it presents a predefined set of exercises and more exercises to achieve mastery. Figure 2.4 shows LISP module interface of APT.
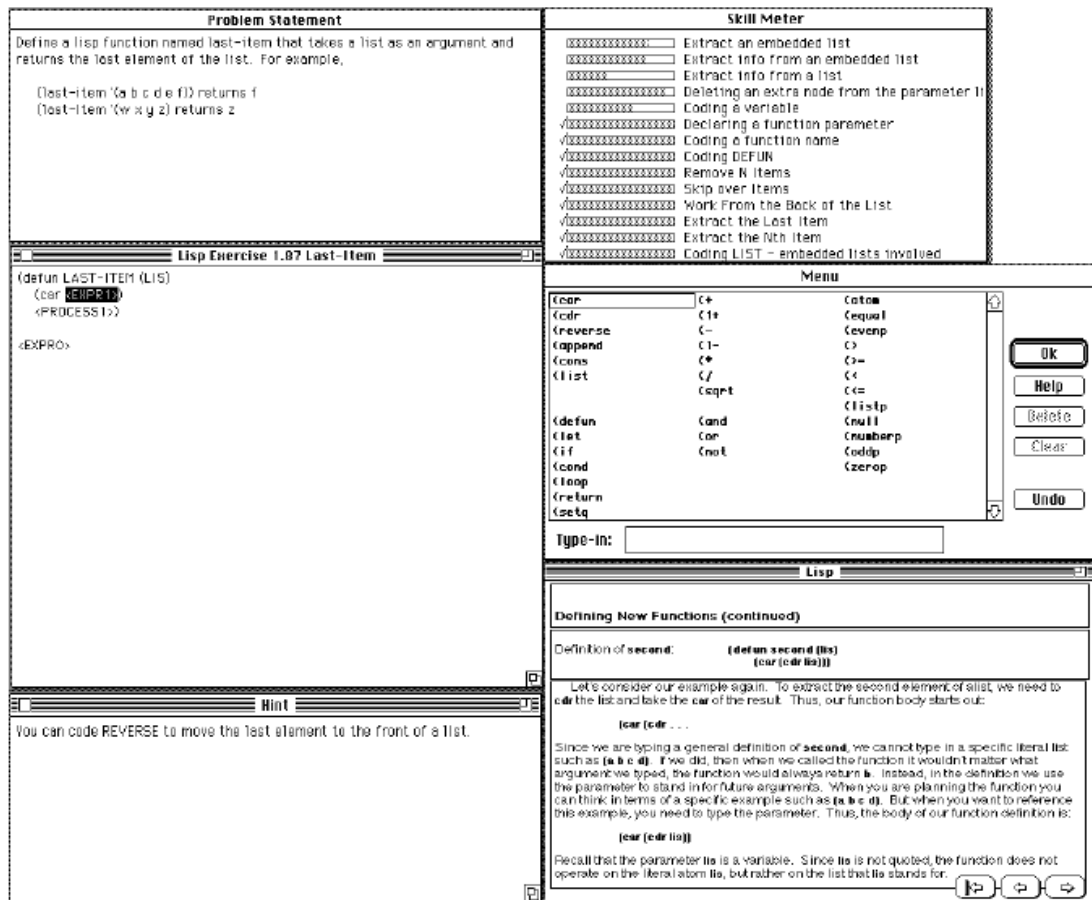
Figure 2.4 : Lisp Module Interface of APT

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RUR-PLE

RUR-PLE (Rossum's Universal Robots – Python Learning Environment) is an educational program developed by Andre Roberge in 2004. This also uses the concept of Karel the Robot. The student can write Python programs to control the robot that moves through a grid. That makes the learning more interesting. This is very similar to GvR, but contains all the concepts (syntaxes) of Python. RUR-PLE provides a fixed sequence of lessons for the students. The learning / teaching process doesn't change according to the students' competency level. Also the feedback and instructions given by this system are not personalized for each student. Figure 2.5 shows RUR-PLE Interface.
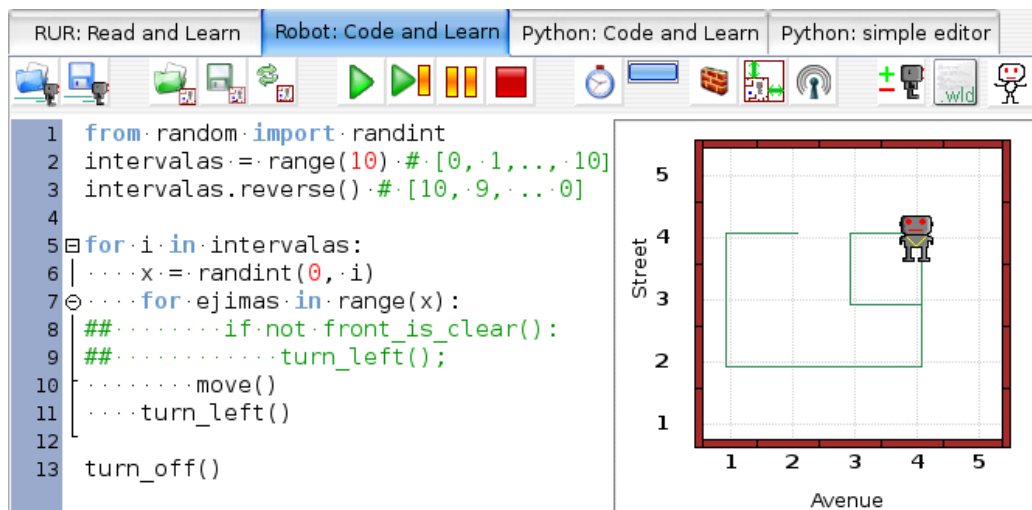
Figure 2.5 : RUR-PLE Interface

GvR
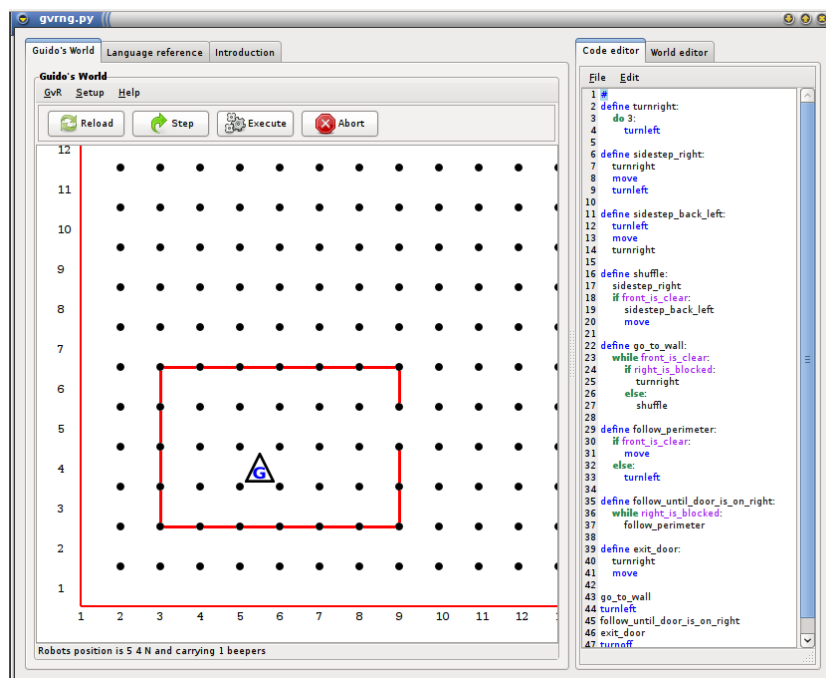
Figure 2.6 : GvR Interface

GvR (Guido van Robot) is an educational tool that developed to learn Python. It has used the concept of Karel the Robot. It is an interactive tool and has developed to learn basic concepts of programming such as sequence, selection, iteration, procedural abstraction, etc. All syntaxes of Python cannot practice using GvR. But this system gives a personalized feedback to the student. Figure 2.6 shows the GvR Interface.

ELM-ART

ELM-ART (ELM Adaptive Remote Tutor) is a WWW based ITS which designed to teach Lisp. This can be considered as on-line intelligent textbook with an integrated problem solving environment. It represents all the learning materials in hypermedia form. ELM-ART provides feedback on request and gives several levels of hints by identifying complete and incomplete solutions. It supports example based programming and provides advanced testing and debugging with intelligent analysis of problem solutions. Figure 2.7 shows a Form-based interface for problem solving support in ELM-ART.
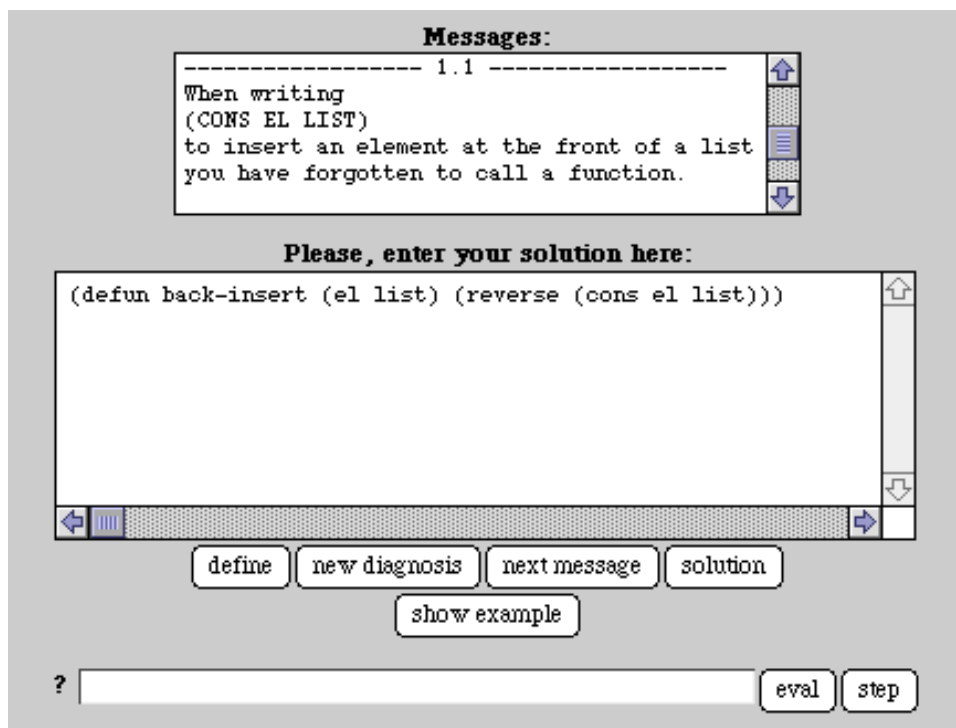
Figure 2.7 : Form-based interface for problem solving support in ELM-ART

Following Table 5 highlights a summary of all the features and programming languages supported by the above discussed ITSs.

Table 5 : Summary of ITSs

	Languages	Exercise Selection	Feedback
C-Tutor	C	According to the students current knowledge level	On Request
ACT Programming Tutor	LISP, Prolog, Pascal	Not according to the knowledge level. Gives exercise only at the end of each section	Immediate
RUR-PLE	Python	Fixed sequence of lessons	Not Personalized
GvR	Python	Only gives exercises for simple programming concepts	Gives Personalized feedback
ELM-ART	LISP	According to the students current knowledge level	On request and also gives several levels of hints

2.2   PROBLEM DOMAIN

ESOFT Metro College – Battaramulla Branch provides various level of academic courses for both school students and school leavers. Courses offered by the institute varies from government national level examinations such as Information and Communication Technology (ICT) subject for both Ordinary Level (O/L) and Advanced Level (A/L) students, Diploma/Higher Diploma courses, both Local/Foreign affiliated Degrees and etc. Python programming language is one of the common option among those various courses teach under the institute. All most all of the addressed courses include basic Python learning content such as variable handling, printing, operators (arithmetic, assignment, comparison, logical, boolean, etc.), operator precedence, if conditions, looping structures, data structures, functions, etc.

Python was included into the government national level examinations after the newest syllabus revision made by the Education Department. But the statistics of recent years shows that the number of students selecting the ICT subject is considerably decreasing because of the fear on learning programming related subject content. And also student fail achieving higher grades because of the lack of support to python programming at school level.

Because of the failing rates in programming subjects areas are bit high compared to other IT subjects areas, students are more likely to drop programming related subjects. But as

programming is included in any sort of the IT related courses, encouraging and supporting students on those difficult areas are important to produce competitive workforce to the industry.

Evaluation of those various courses done as written exams, online exams as well as in the form of assignments. But history results obtained by students shows significant level of unsatisfactory as most students able to score less than 50% for their python module/course assessment. Lack of proper feedback mechanism leads for poor performance too. If we can provide continuous feedback throughout course time then students can easily get to know about their weaker areas which can improve by them.

CHAPTER 3 : RESEARCH METHODOLOGY

This chapter helps the reader to get full understanding about how the research methodology was selected. It tells step by step procedure of carefully analyzing and building a suitable methodology to achieve the objectives of this research. In the analysis stage of Intelligent Tutoring System there are several things to consider. First thing is analyzing the problem. Under this we have to analyze the learner's characteristics and the programming language concepts that need to teach to the student by the system. Then have to analyze and categorize task that need different type of cognitive skills from the learner such as problem solving, decision-making, attention and memory.

Secondly have to consider about the program analysis. The objective of the Intelligent Tutoring system is teaching python programming for students. So it has to analyze the answers given by the student. This chapter describes about learner analysis and the methodology used to analyze students answers.

Finally we have to consider the system as well as user requirements of the proposed system. As we have already completed the literature review and the basic research now we have to map the requirements collected in to relevant section. The section also address requirements as Functional, Non-Functional, Hardware and Software requirements which must be fulfilled in order to develop the identified functionalities of the system.

Mainly this chapter content is divided as system analysis and research designing so the reader will be able to gather the detailed information related to those phases of research easily. It also covers the database structure of the proposed solution. Overall logical architecture of the planned solution is also discussed before moving into the actual implementation of the system. How we move from problem to the solution is also included as a part of this chapter.

3.1   RESEARCH METHODOLOGY

Conducting research focuses on the selecting appropriate research methodology also. Because there are various types of research methodologies available namely quantitative research and qualitative research. The research outcome varies based on the research methodology that we pick. And also the significant of research rely on the research methodology that is use to conduct the research. Conducting a basic fundamental research doesn't help to achieve all the research outcomes. It will only support completing the research work at a glance.

Quantitative research primarily focus on numeric data [20], [21]. Before deciding the neediness of this kind of an ITS, pass rates of students who take python course at the institute and individual student grading compared to other modules over programming also taken into account. Conducting students surveys about the python lecture series and their results, allowing the students to submit a completed questionnaire are used to conduct the quantitative research. Quantitative research can be used to gather the personal view and attitude about the python course that they follow in institute. So it can easily be used to study about their feeling about the course content and the feedback it gathered by learners' viewpoint. Several interviews were conducted to get the concerns and ideas of the actual learners. In this qualitative research will be helpful to get deeper understanding about how they feel about the python course and it can be useful to take further actions to improve the teaching process. Building and talking with a focused group and personal interviews are some techniques used in this context. But both quantitative and qualitative research methodologies are used when working with development oriented projects. But for research projects we need some border approach when picking the most suitable research methodology.

So in this context it was selected the combination of two research paradigms namely Use Inspired Basic Research (UIBR) methodology and Applied Research methodology. The reason behind selecting the above two research methods as a combination is because, each method will have its own limitations that can be covered using the other approach.

In general basic research can be expressed as a systematic study but UIBR is extended the work of a basic research by an ultimate application, meaning in our case KB formulated by fundamental research can be motivate/extended by an innovative application to enrich its research objectives. It is useful when developing insights using basic knowledge. The methodology take system requirements as the inputs and gives basic insights as the result. But use inspired methodology affect when there are stakeholders with conflicting priorities. While fundamental study focuses on the existing problems and knowledge in the domain and applied research focuses on resolving those issues gathered during basic research or improving the existing knowledge. And applied methodology focus on solving specific immediate problem and are bound with tight deadlines. So mixing those to approaches and using it collectively helps us achieving the primary objectives of this research.

Finally the research methodology it follows in this research is labelled as Use Inspired Applied Methodology. There are several work that must be planned and carried during this research time. It was fully described in the research design section. Because there are some

phases associated with the research work about to be completed during research and the selected methods will be used during various intervals to get the desired outcome of such phase. The selected methodologies will be used throughout while working on the solution building and the suitability of the approach is evaluated as part of the process.

3.2   SIGNIFICANCE OF RESEARCH

After conducting the research following conclusions are made. Need to implement an optimum way of generating and presenting the feedbacks for the learners. Because feedback is a key component to the success of an ITS. Then the learner can experience the same sort of guidance while learning python programming using the developed tool. As there will be alternative solutions to a given task in IT'S the feedback must also be adjusted based on the answer that student provide for each activity. Feedback must be ongoing with the activities so the shaping of learning through proper feedback will be carry forward to the future activities where the students do with the progression of the course. And the feedback must be student specific it must be tailored to a particular student. Need for best use of Human Computer Interaction (HCI) principals are also required for presenting the feedback in the most effective way.

Addressed pedagogical theories must be implemented alone with the ITS so the best teaching practices will be available in the developed ITS too. System must cater the user with best combination of technology so that they can continue to use the system in their convenient time.

During research it was identified that before evaluating the performance of the students in various activities they will be entitled for a practice session on the relevant area of study. Because it enhance the capability of learner achieving better results. Particular students' knowledge level is measured and updated with the progression of the course activities. So the resulting solution will have a custom methodology to retrieve the student knowledge level while completing each activity using an ITS.

Based on the research conducted final conclusion has made to develop an ITS system by considering the feedback mechanism and combing the best teaching approaches in an online environment where student will not feel any form of difference from a physical classroom environment and how it operates. Following section describe how the approach was planned and executed based on the judgement criteria of achieving the research outcome.

3.3   RESEARCH APPROACH AND DESIGN

As we already discussed conducting a research is not a straightforward process. It have to be planned accordingly to achieve the expected results. During this approach it was decided to break the entire work to be conducted into following manageable chunk of Work Breakdown Structure (WBS). WBS helps to keep the scope of the project as a constant. Having a well-defined research approach leads to obtain the expected outcome without any conflicts. Formulating the research methodology fit into the work to be performed, enrich the work procedure. Following are some key processes identified to be handled as separate phases of the research.

- Formulating a focused group
- Checking the sustainability of the approach using focused group
- Refining the approach using the feedback from the focused group
- Prioritizing the research objectives
- Creating a WBS
- Implementing a workable solution
- Formulating the research outcome and results
- Evaluating the solution using the focused group
- Revising the solution with feedback from focused group
- Evaluating the solutions using the entire learner population
- Revising the solution with the feedback from the entire learners
- Finalizing, documenting and terminating the research
- Etc.

Above WBS will be used when continuing the research from this point onwards. Each work process will complete a partial successive phase of the research. At the completion of each phase it must ensure that primary research objectives are met during the recently completed activities. Evaluation of the work performed is necessary to ensure that level of work completed is in-line with the planned work to be performed during that specific stage. Initial plan was set to implement an ITS for python programming, but research is focused on the feedback perspective of the implemented solution. So it have to carefully concentrate on about the research methodology and its approach of conducting the research, it uplift the richness of the result obtained than doing a simple implementation project. When designing the research approach we have to analyze the existing process and its architecture clearly before making further decisions and actions.

Once after successful completion of deep analyzing process, solution is ready to be modeled with a suitable design approach and methodology. In general basic research only support establishing theories based on hypothesis, but more vastly applied research formulate procedures to solve practical issues and consequences based on the demanding knowledge on those work domains. So our research is conducted baseline of applied research principals and procedures so learner exercise attempt actions and knowledge gathered through those activities will be used to achieve the objective of providing the most suitable feedback in the most suitable presentable format where the primary objective of the research will be met by conducting and obtaining the results of the research using the defined approach.

Results of the research will be useful to formulate new theories and concepts based on what we have achieved while conducting the research. Those new artefacts can be used to solve the practical problems in the existing environment. Finally some results can also be used to formulate new hypothesis also. Deriving the solutions based on the input parameters are described as a part of the problem analysis section. To do so concept and the development procedure and the impact of the results gained by the solution to those existing issues are address in the below sections. Impact means the evaluation part of the research that ensure primary research objectives are being achieved. Some of those added content are organized for the researchers who are interested on the same area of study to improve the research outcome in the future. Some of the technical difficulties and shortages in the current platform are identified and documented so during the implementation of the new system it can be considered as some constraints which have to be kept neutral to avoid research moving into no result based situation.

When building the logical solution it is very important to define appropriate framework and system architecture. Because the total solution is depends on how we organize the solution architecture and it will eventually effect on maintainability of the solution as well. Some part of development have to touch the basic phases of System/Software Development Life Cycle (SDLC) also. But it won't convert the shape of the project into a development project from research project paradigm. Some can argue that it also in the nature of System Development methodology too. Following are actual work performed based on the WBS activities listed in the beginning of the section. They are the real work performed according the WBS related phases of this research. Time allocated for each work activity is defined during proposal stage and are closely monitored at the completion of each activity and necessary adjustments have to be made to keep it strict to the initial time plan. That is why architecture building and

approach/methodology selecting plays crucial part of a research project. It can completely avoid/minimize repeating and unnecessary work during project time.

Formulating a focused group phase focused on selecting a small learner group to contribute to the success of the research. Checking the sustainability of the approach using focused group is the process of evaluating the selected approach [21]. For that it can use standard methods like questionnaires. Refining the approach using the feedback from the focused group is the process of realigning the approach based in the valuable comments from the focused group. Prioritizing the research objectives phase is there to rearrange the objectives form the highest to the lowest priority order where high priority work can be addressed and treated first. Creating a WBS is useful to break the work into manageable work modules. Now the real implementation begins. Implementing a workable solution means developing the proposed system by covering all the needs of the stakeholders. Formulating the research outcome and results is the process of evaluation of work carried during research to see whether objectives are met or not. Evaluating the solution using the focused group is also a part of previously specified phase. Revising the solution with feedback from focused group is similar to the refining the approach. Focused group audience feedback can be taken into action to do necessary fine-tunes. Once focused group is ok with the results and the research becoming into an accepted level then it will be tested by the actual users rather than only a sample population. Evaluating the solutions using the entire learner population and Revising the solution with the feedback from the entire learners phased are reserved for that. Finally finalizing, documenting and terminating the research will be the last phase of the research before it is officially announced as closed.

Those work modules are planned to perform in order to obtain the expected results as planned. But it is a known factor that there are development projects goes smoothly as expected during planning stages. Certain level of adjustments and shaping have to be made to keep the research conducted on track under a manageable scope. Some of the detailed phases which comes with sub phases are described in the implementation chapter because information required for such activities can only be gathered during the real implementation of the project.

As now appropriate research approach and methodology is set and finalized lets focus on more detail areas about analyzing the real problem and solution building approach which can be carry forward until the completion of the research. Following sections are designed to achieve the necessary knowledge to formulate the architecture of the proposed solution.

3.4   ANALYSIS OF THE PROBLEM

To understand the characteristics of learners, a learner analysis has been conducted. A questionnaire was given to selected learners (focused group) and summarized and analyzed the information collected from sample learner groups [20].

30 students have been selected for the learner analysis. They are from both genders male and female within the age range of 16 to 20. All of them are IT students in different levels and with mixed abilities.

The questionnaire that has been given to sample learner group for leaner analysis is attached in Appendix A.

By analyzing the data collected through learner analysis, it can be seen there are students in different gender, different age limits with different educational levels. Since they are all Sri Lankans their primary language is Sinhala or Tamil. So the Intelligent Tutor should be in simple English language which can understand by average level student.

All the selected people are from IT background. So they have learnt IT through several years ranging from 1- 10 and most of them has computer literacy. But most of the students who are in O/L, A/L and Diploma Level don't have prior knowledge in programming or Python language. So the main focused group who get the real benefit of the proposed ITS development will be the student category who are novice learners to python programming.

Majority of the sample analyzed prefer learning by self-studies. Almost all have internet connections at home and uses internet frequently for their work. So it is worthwhile to implement the Intelligent Tutoring System as a web based solution.

When considering about the ratings of the students for their metacognitive skills, it can be concluded as all are normal people with average level of metacognitive skills such as Perception, Attention, Memory, Visual & Spatial Processing, Planning, Monitoring, Problem Solving, Decision Making, and Sequencing. Also they have mentioned that none of them have learning disabilities and cognitive disabilities.

Results of the learner analysis can be shown in following charts.

Learner Analysis Results

Category	Value	Student Count
Online Experience Level	Never	0
	Rare	0
	Frequent	30
Availability of Internet Connection	No	0
	Yes	30
Preffered Learning Style	Self Learning	21
	Classroom	9
Experience with Python	No	25
	Yes	5
Programming Level	Advanced	0
	Intermediate	1
	Beginner	29
Computer Literacy Level	Advanced	1
	Intermediate	7
	Beginner	22
Education Level	Diploma	2
	A/L	11
	O/L	17
Primary Language	Tamil	4
	Sinhala	26

3.5   COGNITIVE TASK ANALYSIS

Cognitive task analysis (CTA) is a category of task analysis focused on understanding tasks that require a lot of cognitive abilities of the user, such as decision-making, problem-solving, memory. Cognitive task analysis is a new tradition to distance learning programs. When handling online education programs with e-Learning, it is combined with Instructional Designing (ID) process. ID also called as Instructional System Designing (ISD). It mainly focuses on creating rich educational content which in line with cognitive content. Primary aim is to decide how to organize and structure the information presented in educational system [22]. Cognitive task analysis is useful when allowing novice learners solve real world tasks and perform well in the domain. To develop the teaching model expert teachers can be observed to identify how they react on complex situations while teaching. It analyzes how the expert knowledge is used while teaching [23].

By identifying the mental model of the learner cognitive task analysis observe the behavioral aspects of the leaner and mix the cognitive skills to tackle the challenging situation while learning process. It can be used with knowledge representation and to perform complex tasks easily. Also it flow the learning model in the dynamic nature rather than linear flow of activities.

According to the author expressed cognitive process and phases are like the below. Following are the main phases of cognitive task analysis [24].

- Background Preparation
- Elicitation of Knowledge
- Analysis of Qualitative Data
- Knowledge Representation
- Design & Develop Applications

In background preparation we focus on the problem domain and target audience who are going to use the solution. Elicitation of knowledge focus on getting the knowledge formed by closely working with Subject Matter Experts (SME) to formulate the knowledge and to prepare the tactic knowledge of solving problems/decision making. Analysis of qualitative data works with vast volume of data and to define the goals, strategies, concepts, decisions and etc. Assembling and formulating the knowledge in readable and understandable format using representable notations like tables, charts and diagrams are identified as knowledge representation. Finally it is about ID. We focus on about delivering the knowledge to the

learners as the content of the platform. When developing the platform we need to think it form the learner perspective as well as subject teacher perspective. Because the expert knowledge must be mapped accordingly to the students' knowledge level and must be adjusted to the varying needs of individual learners. For that performing cognitive task analysis is highly required.

According to author expressed in research [25] of how experts differ from the novices following seven key areas were discovered. They mainly differ broadly based on the factors;

- When generating the best solution to a given problem or when designing a solutions to a task
- Locating and identifying features which novice usually doesn't notice
- Conducting deep level of analysis before take any actions to tasks
- More skills when self-monitoring, detecting errors in their own work
- Picking more appropriate strategies during task completion
- Looking some other possible solutions, alternatives and information sources related to problem solving
- Able to gain more knowledge and skills with minimal cognitive effort and control, during challenging situations.

So the cognitive process minimizes the conflictions that may lead when identifying the particular learner knowledge level related to a specific task. Most common cognitive decisions can be decided by conducting structured interviews with SME. A group of Python teachers have been selected for this task and collected the knowledge from them to prepare efficient subject content. Also subject content has been divided in to knowledge components which can be easily transferrable to students. Those knowledge components and subject contents are attached in Appendix B.

So the research is mainly focused on the qualitative research paradigm. But some level of observation too has been incorporated to generate strong analysis before finalizing what actions must be taken to produce the best possible solution to the addressed research questions. It helps to adjust ITS based on the learner knowledge level automatically.

3.6 PROGRAM CODE ANALYSIS

An external tool was used for this analysis of computer programs written by students. Grammar files which are used during program analysis were developed using ANother Tool for Language Recognition (ANTLR) which is a tool that supports the creation of grammar files. ANTLR allows the creation of ASTs from the code supplied as a text. ANTLR creates outputs that are suitable for program analysis.
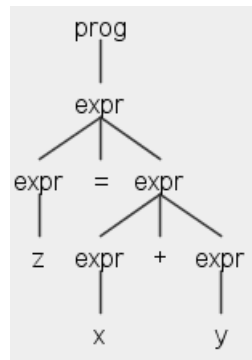
Figure 3.1 : AST generated by ANTLR

3.7 FUNCTIONAL REQUIREMENTS

Functional requirements cover the functionalities of the proposed system. It describe what functionalities that the developing system able to perform. They must be aligned with the user requirements. In general it covers the basic user needs/functions by an ITS for python programming. Those functions are respect to input and outputs of the relevant functionality. It can also be described as the outcomes, components of the system which is going to implement. Following are some general functional requirements which are identified during the analysis process.

- Facilities to capture the learner knowledge level and to customize the activities accordingly
- Facilities to suggest the exercises
- Facilities to practice lessons and key areas of the python course
- Facilities to monitor the progress of the course by the leaners
- Provide ongoing individual feedback based on users activities
- Providing best learner wise activity/exercise selection
- Facilitate the learners to collaborate with their peers and teachers while participating for activities/exercises
- Allow SME to react and guide learners while taking exercises

- Provide mechanism to reward the learners for their achievements
- Providing shortcuts to access certain functionalities
- Facilities to deliver the feedback in the most suitable medium to individual learners

3.8 NON-FUNCTIONAL REQUIREMENTS

Non-functional requirements are the qualities that the developed system must maintain. It tells how the system must work according to the specification. They can be mainly expressed as quality attributes/characteristics. Usually unlike functional requirements, non-functional requirements are hard to measure/judge. It will ensure that the possibility of reaching the functional requirements in to a satisfactory level as they are some behavioral factors of the proposed system. Some of the main non-functional requirements which must be fulfilled using the python ITS are;

- Accessibility
- Consistency
- Performance
- Availability

- Maintainability
- Reliability
- Safety
- Usability and etc.

3.9 SYSTEM REQUIREMENTS

In general computer software projects there are some hardware and software requirements needs to be fulfilled for both development and runtime environments. Those are labeled as system requirements. Following section describes the minimum requirements that the system must meet. System requirement are categories in to two broader categories hardware and software requirements and each category covers the development and runtime requirements separately.

Hardware Requirements

Development Environment

- Intel i5 3.0GHz bases system
- 4GB RAM
- 40GB HDD free space

Runtime Environment

Proposed system will be implemented under subdomain of https://www.esoftbattaramulla.lk. And it will be accessed via https://www.esoftbattaramulla.lk/pits/ by all the users and for runtime PCs/Laptops it is recommended to have at least i3 processor based system with minimum of 4GB RAM for better performances.

Software Requirements

Development Environment

XAMPP version 5.6 will be used. It includes Apache server 2.4, PHP 5.6, MySQL 5.6 and PHPMyAdmin 4.2 in its basic setup. For developments PHP will be used as the core programming language. For layout creation BOOSTRAP version 3.3 framework will be used. It includes the necessary CSS files required for interface preparation. And for client side scripting jQuery version 3.3 will be used. It includes the necessary JS files required for client side scripting work. ANTLR version 4.7 and JDK version 1.8 will be used to prepare the AST and the compiled version of the learner given python code and to get the final output of the executed code. System will check on most modern web browsers including Mozilla Firefox, Google Chrome and Internet Explorer (IE). To setup certain configuration windows command prompt will be used and all installations will be on top of Windows 10 64bit Operating System (OS). Notepad++ will be used as the text editor for coding the solution.

Runtime Environment

In runtime environment ANTLT version 4.7, JDK version 1.8 and any of the above mentioned web browser can be used. For best performance users are advised to use any OS Windows 7 64bit upwards. To avoid students misuse the ITS all runtime environments are implemented without any python local installation.

3.10   DATABASE DESIGN

This section describes the database (DB) structure of the proposed python ITS. Section covers the table descriptions and their relationships. Tables are created after performing the basic level of normalization to the table structures. Tables are used to hold the student knowledge level, activities information and exercises related to various course content in the python programming subject. The amount of time that each student spent on the platform, the level of collaboration that they did with peers, student rewarding information are some of the data

available in the DB of the proposed ITS. To implement the DB, MySQL Database Management Systems (DBMS) is used with PHPMyAdmin Graphical User Interface (GUI) to manage the DB. Following Table 8 lists the system tables, their fields and the data types which is set to suite for the system functionalities.

Table 6 : Python ITS Proposed DB Table Structures

Table Name	tblBatch			
Field Name	Data Type	Primary Key	Auto Increment	Default Value
BatchID	int	Yes	Yes	
BatchName	varchar(50)			
Course	varchar(10)			
Lecturer	int			
Table Name	tblCourse			
Field Name	Data Type	Primary Key	Auto Increment	Default Value
CourseCode	varchar(10)	Yes		
CourseName	varchar(200)			
Table Name	tblExerciseAnswers			
Field Name	Data Type	Primary Key	Auto Increment	Default Value
ExerciseID	int	Yes		
AnswerID	int	Yes		
Answer	text			
BestAnswer	char(1)			N
Table Name	tblExercises			
Field Name	Data Type	Primary Key	Auto Increment	Default Value
ExerciseID	int	Yes	Yes	
QuestionType	int			
QuestionSubType	int			
ExerciseDesc	text			
ExerciseImage	varchar(10)			
ExerciseLevel	int			

Table Name	*tblExerciseStudAnswers*			
Field Name	**Data Type**	**Primary Key**	**Auto Increment**	**Default Value**
UID	int	Yes		
Exercise	int	Yes		
Attempt	int	Yes		
Answer	text			

Table Name	*tblExerciseStudAttempts*			
Field Name	**Data Type**	**Primary Key**	**Auto Increment**	**Default Value**
UID	int	Yes		
Exercise	int	Yes		
Attempt	int			
CompletedStatus	char(1)			N

Table Name	*tblExerciseStudErrors*			
Field Name	**Data Type**	**Primary Key**	**Auto Increment**	**Default Value**
UID	int	Yes		
Exercise	int	Yes		
Attempt	int	Yes		
Error	text			
Feedback	text			

Table Name	*tblExerciseTokens*			
Field Name	**Data Type**	**Primary Key**	**Auto Increment**	**Default Value**
ExerciseID	int	Yes		
Tokens	text			

Table Name	*tblFeedback*			
Field Name	**Data Type**	**Primary Key**	**Auto Increment**	**Default Value**
FID	int	Yes	Yes	
UID	int			

Subject	varchar(200)			
Message	text			

Table Name	*tblLecturer*			
Field Name	**Data Type**	**Primary Key**	**Auto Increment**	**Default Value**
LecID	int	Yes	Yes	
LecName	varchar(150)			
LecImage	varchar(32)			

Table Name	*tblLogin*			
Field Name	**Data Type**	**Primary Key**	**Auto Increment**	**Default Value**
UID	int	Yes	Yes	
UserName	varchar(32)			
Password	varchar(64)			
Email	varchar(100)			
FullName	varchar(150)			
LastAccess	datetime			
Duration	time			
Batch	int			
PreTestCompleted	char(1)			N
PreTestMks	decimal(5,2)			

Table Name	*tblMessage*			
Field Name	**Data Type**	**Primary Key**	**Auto Increment**	**Default Value**
MID	int	Yes	Yes	
UID	int			
RUID	int			
Subject	varchar(200)			
Message	text			
SentDate	date			
ReadStatus	char(1)			N

Table Name	tblPracticeSessions			
Field Name	**Data Type**	**Primary Key**	**Auto Increment**	**Default Value**
PID	int	Yes	Yes	
UID	int			
PracticeDate	date			
PracticeDuration	int			
Table Name	tblPreTestAnswers			
Field Name	**Data Type**	**Primary Key**	**Auto Increment**	**Default Value**
QuestionID	int	Yes		
AnswerID	int	Yes		
Answer	text			
IsCorrect	char(1)			N
Table Name	tblPreTestQuestions			
Field Name	**Data Type**	**Primary Key**	**Auto Increment**	**Default Value**
QuestionID	int	Yes	Yes	
QuestionType	int			
QuestionSubType	int			
QuestionLevel	int			
QuestionDesc	text			
QuestionImage	varchar(10)			
Table Name	tblPreTestStudAnswers			
Field Name	**Data Type**	**Primary Key**	**Auto Increment**	**Default Value**
UID	int	Yes		
Question	int	Yes		
Answer	int	Yes		
Table Name	tblQuestionSubTypes			
Field Name	**Data Type**	**Primary Key**	**Auto Increment**	**Default Value**
QuestionTypeID	int	Yes		

QuestionSubTypeID	int	Yes		
QuestionSubType	text			

Table Name	*tblQuestionTypes*			
Field Name	**Data Type**	**Primary Key**	**Auto Increment**	**Default Value**
QuestionTypeID	int	Yes	Yes	
QuestionType	text			

Table Name	*tblSkillLevels*			
Field Name	**Data Type**	**Primary Key**	**Auto Increment**	**Default Value**
UID	int	Yes		
QuestionType	int	Yes		
QuestionSubType	int	Yes		
SkillLevel	decimal(5,2)			

Table Name	*tblStudentAchievements*			
Field Name	**Data Type**	**Primary Key**	**Auto Increment**	**Default Value**
AID	int	Yes	Yes	
UID	int			
Achievement	int			
AchievedDate	datetime			
MarksGained	int			

Table Name	*tblTips*			
Field Name	**Data Type**	**Primary Key**	**Auto Increment**	**Default Value**
TID	int	Yes	Yes	
TipTitle	varchar(150)			
TipDesc	text			
TipURL	varchar(255)			

CHAPTER 4 : IMPLEMENTATION

This chapter describes the actual implementation of the Python Intelligent Tutor along with the user interface designs and its learning context/exercises. It describes the way that the system communicates with the user interfaces and other components. Section 4.1 describes the process of how the implementations of the system initiated. Rest of the chapter content describe how the actual development work is carried on in order to complete the proposed system. Functionalities are developed based on the research questions which are addressed in literature study which was conducted. Implementation is carried on top of open source platform due to the licensing issues and the vast amount of community support available on such platforms. It also considered the platform independence of programming language used to support the system by most standard operating systems.

4.1   LAUNCHING THE IMPLEMENTATION

We already identified the hardware and software requirements for the proposed system in the previous chapter. Now we are about to launch the implementation of the planned system. The process of development will be based on Research and Development (R&D) nature. It will cover the tasks like interface designing, building the database & tables, writing the system core modules and implementing the functionalities of the proposed system. Based on the literature study conducted it was identified that primary aim of the system is to provide adequate level of feedback in a most suitable presentable format. The exercises which are designed have to be decomposed with careful guidelines defined by SME.

So the interfaces and screen components which deals with the specified dilemma must be compatible with the HCI and Universal Design (UD) principals. So it was decided to build all interface and screen elements using Bootstrap open source toolkit version 3.3.7. When generating graphs, it focus on CanvasJS version 2.0.1 commercial module. The factors behind selecting such tools/frameworks for our development is, the proposed system will be a web based solution and the resulting system will work on top of web browsers. For graphical management of DB, phpMyAdmin GUI tool will be used.

Once all interface designing completed immediately all interfaces are checked for cross-browser compatibility to ensure that all screens provides the same visual experience in all common web browsers with their latest versions. It ensures the accessibility of developed system. But all development is carried on Mozilla Firefox to minimize the effort on making

the system compatible with other popular web browsers like Google Chrome and Internet Explorer current latest versions.

4.2 THE PYTHON INTELLIGENT TUTOR INTERFACES

The Intelligent Tutor for Python is a web based system. Students have to access it through a web browser. In order to use the system student has to create a user account with a user name and a password. Then student can log in to the system using that user name and password. Login form and Registration form are shown in Figure 4.1 & Figure 4.2.
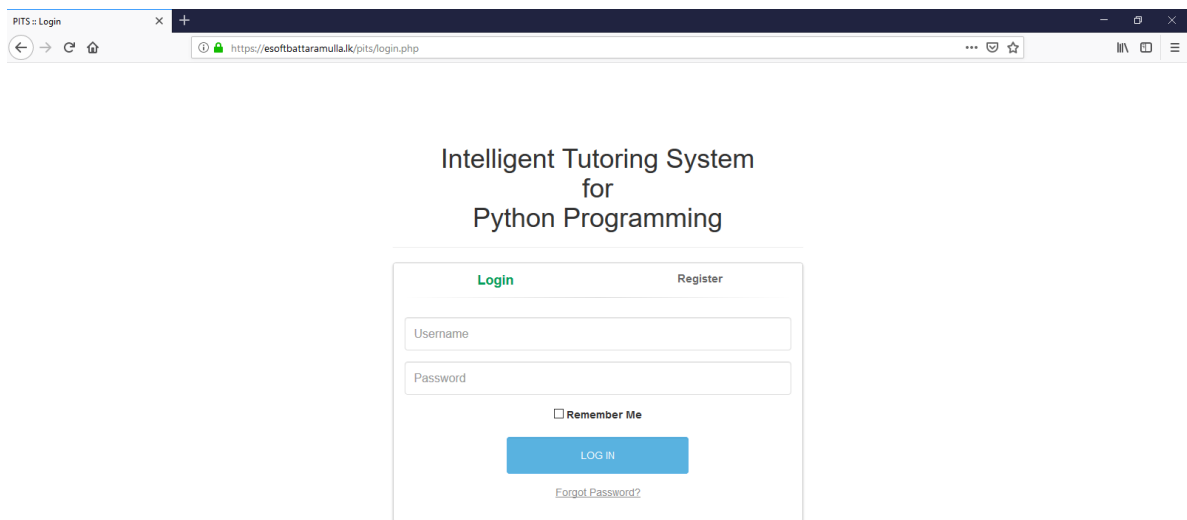
Figure 4.1 : Login Page of Python Intelligent Tutoring System

During literature study it was identified that allowing peer communications and collaborations helps the learning process effectively. For the purpose of maintaining the direct feedback given by subject teachers in physical class environments, newly developed system will implement the account creation based on their courses and batch details. So it allows the opportunity to maintain the lecture data associated with those batches. When providing feedback during exercises, they will visually see their teacher photo while getting their personalized feedback during those activities. Following Figure 4.2 shows the Registration data gathered during registration process.
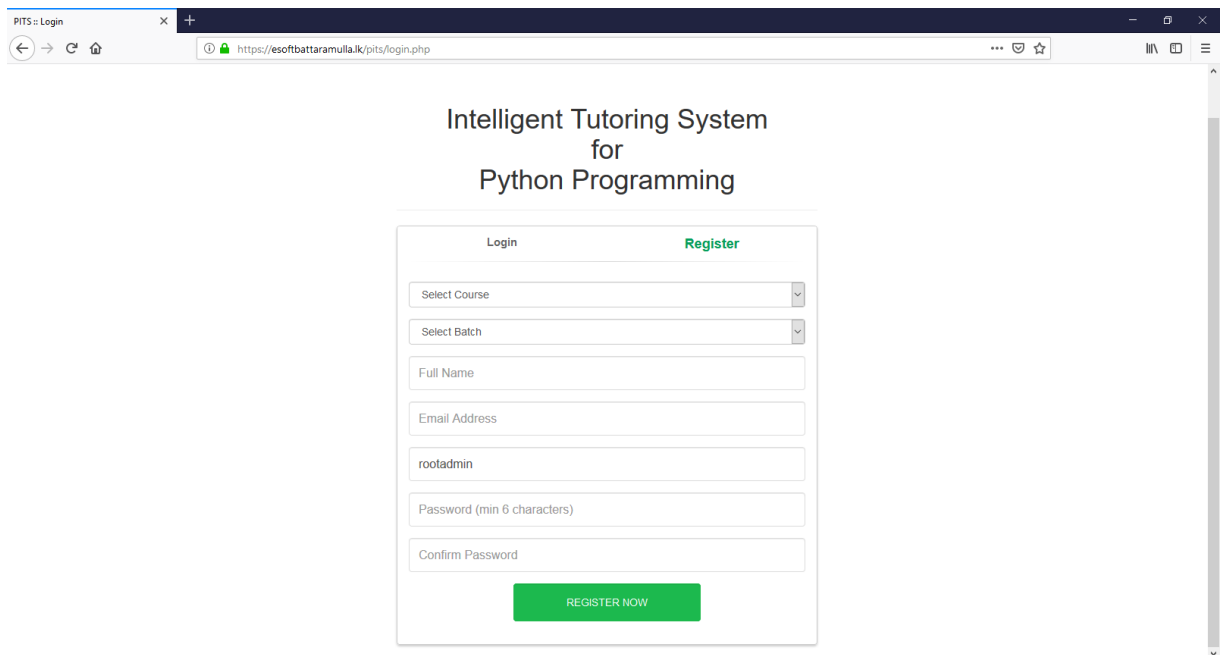
Figure 4.2 : User Registration Form

As the above sections are common for all most all web based systems, no code explanation is included alone with above two sections. When logging into the system for the first time, student require completing a pre-test to measure the current python knowledge. Test page is shown in Figure 4.3. That test is based on multiple choice questions and student can select the answer from given options. Students are not allowed to leave any question even if he/she doesn't know the answer.
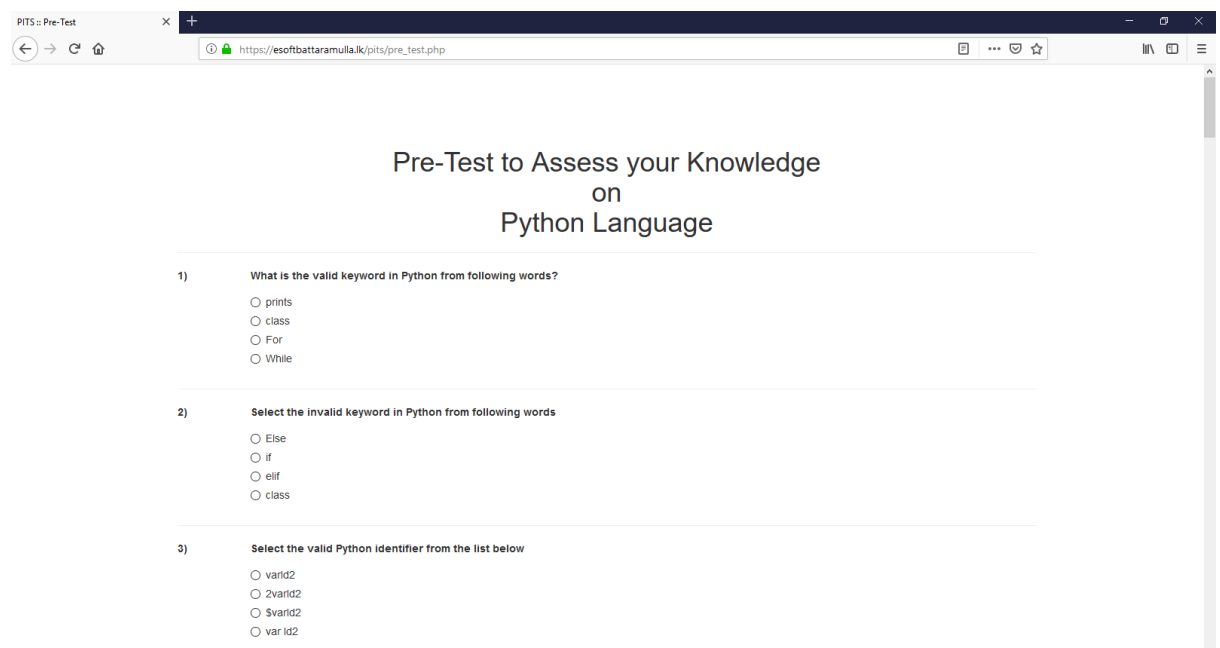
Figure 4.3 : Pre-Test Interface

Following code modules will be used during the process of assessing the initial skill level of individual learner and updating the relevant tables in the DB. Files used for that process is labeled as *pre_test.php*, *pre_test_process.php* and *pre_test_results.php*.

pre_test.php

```php
<div class="form-group">
       <?php
              $noOfQ = 0;
              $sqlQ = "SELECT QuestionID, QuestionType, QuestionSubType,
QuestionDesc, QuestionImage FROM tblPreTestQuestions";
              $resultQ = $con->query($sqlQ);

              if ($resultQ->num_rows == 0)
              {
                     // No questions
              }
              else
              {
                     $noOfQ = $resultQ->num_rows;
                     while($rowQ = $resultQ->fetch_assoc())
                     {
       ?>
       <div class="row">
              <div class="col-sm-1">
                     <b><?=$rowQ['QuestionID'];?>)</b>
              </div>
              <div class="col-sm-11">
                     <label class="control-label"><?=$rowQ['QuestionDesc'];?></label>
                     <?php
                     if($rowQ['QuestionImage'] != '')
                     {
                            echo "<br /><img
src='images/question/".$rowQ['QuestionImage']."' />";
                     }

                     $sqlA = "SELECT AnswerID, Answer FROM tblPreTestAnswers
WHERE QuestionID='".$rowQ['QuestionID']."'";
                     $resultA = $con->query($sqlA);

                     if ($resultA->num_rows == 0)
                     {
                            // No answers
                     }
                     else
                     {
                            while($rowA = $resultA->fetch_assoc())
                            {
                     ?>
```

```
                          <div class="radio">
                           <label>
                                <input type="radio"
id="<?=($rowQ['QuestionID'].'||'.$rowA['AnswerID']);?>"
name="pre_test_answers[<?=$rowQ['QuestionID'];?>]"
value="<?=($rowQ['QuestionID'].'||'.$rowA['AnswerID']);?>" required />
                                <?=nl2br($rowA['Answer']);?>
                           </label>
                          </div>
                          <?php
                                }
                          }
                          ?>
                  </div>
          </div>
          <hr />
          <?php
                  }
              }
          ?>
</div>
```

```
// Checking count of type wise pre-test questions
$arrQTypes = array();
$sqlQT = "SELECT QuestionType, QuestionSubType, COUNT(QuestionID) AS QC FROM
tblPreTestQuestions GROUP BY QuestionType, QuestionSubType";
$resultQT = $con->query($sqlQT);

if ($resultQT->num_rows == 0)
{
        // No question types
}
else
{
        while($rowQT = $resultQT->fetch_assoc())
        {
                $arrQTypes[$rowQT['QuestionType']][$rowQT['QuestionSubType']]        =
$rowQT['QC'];
        }
}

// Checking valid pre-test answers
$correct = 0;

$arrCQTypes = array();
$sql = "SELECT QuestionTypeID, QuestionSubTypeID FROM tblQuestionSubTypes";
$result = $con->query($sql);

if ($result->num_rows == 0)
```

```php
{
        // No question types
}
else
{
        while($row = $result->fetch_assoc())
        {
                $arrCQTypes[$row['QuestionTypeID']][$row['QuestionSubTypeID']] = 0;
        }
}

foreach($_POST['pre_test_answers'] as $key=>$value)
{
        $ansArrPart = explode("||", $value);
        $sql = "SELECT A.QuestionID, QuestionType, QuestionSubType FROM
tblPreTestQuestions Q, tblPreTestAnswers A WHERE Q.QuestionID=A.QuestionID AND
A.QuestionID='".$key."' AND AnswerID='".$ansArrPart[1]."' AND IsCorrect='Y'";
        $result = $con->query($sql);

        if ($result->num_rows == 0)
        {
                // Incorrect Answer
        }
        else
        {
                $row = $result->fetch_assoc();

                // Calculating pre-test marks
                $correct++;

                // Getting the question type based correct answer counts
                $arrCQTypes[$row['QuestionType']][$row['QuestionSubType']]                =
$arrCQTypes[$row['QuestionType']][$row['QuestionSubType']] + 1;
        }

        // Adding the student pre-test answers
        $sql = "INSERT INTO tblPreTestStudAnswers VALUES ('".$_SESSION['uid']."',
'".$key."', '".$ansArrPart[1]."')";

        if ($con->query($sql) === TRUE)
        {
                // record added
        }
        else
        {
                header("Location: pre_test.php?f=e&c=1");
        }

}

//print_r($arrQTypes);
//echo "<br /><br />";
```

```php
//print_r($arrCQTypes);
//echo "<br /><br />";
//exit;

// Adding the student question type based answer counts
foreach($arrCQTypes as $key=>$value)
{
        foreach($value as $k=>$v)
        {
                if(isset($arrQTypes[$key][$k]))
                {
                        $sql       =       "INSERT    INTO    tblSkillLevels    VALUES
('".$_SESSION['uid']."', '".$key."', '".$k."', '".(($v/$arrQTypes[$key][$k])*100)."')";
                }
                else
                {
                        $sql       =       "INSERT    INTO    tblSkillLevels    VALUES
('".$_SESSION['uid']."', '".$key."', '".$k."', '0')";
                }

                if ($con->query($sql) === TRUE)
                {
                        // record added
                }
                else
                {
                        header("Location: pre_test.php?f=e&c=1");
                }
        }
}

// Updating the user pre-test status
$qCount = ((isset($_POST['NoOfQuestions']) && !empty($_POST['NoOfQuestions']) &&
is_numeric($_POST['NoOfQuestions'])    &&    $_POST['NoOfQuestions']    >    0)    ?
$_POST['NoOfQuestions'] : '20');
$sql        =        "UPDATE        tblLogin        SET        PreTestCompleted='Y',
PreTestMks='".(($correct/$qCount)*100)."'" WHERE UID='".$_SESSION['uid']."'";

if ($con->query($sql) === TRUE)
{
        header("Location: pre_test.php?f=s");
}
else
{
        header("Location: pre_test.php?f=e&c=1");
}
```

Above two code blocks are the two main core modules when assessing student knowledge
level and suggesting exercises to improve their knowledge. And the first level of feedback is
provided using ***pre_test_results.php*** script. Following Figure 4.4 show how it is done using

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HCI features. It gives difficulty level of each question and answer status using 3 colour scheme of Bootstrap success, danger and warning. Learner can access the given page after the first visit using the profile section.
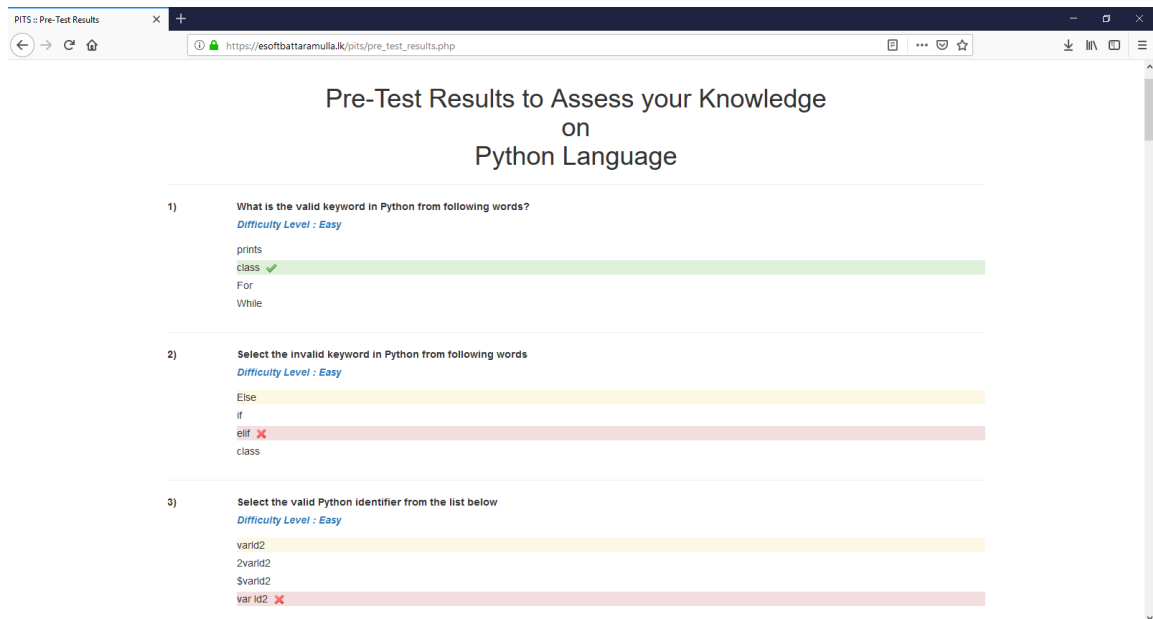
Figure 4.4 : Pre-Test Results Page

After completing the test, student is directed to exercise suggestion page. From the second time onwards this is the page that directly displayed to the student when logged in to the system. Exercise suggestion page is shown in Figure 4.5. The advantage of this page is, it guides the student towards the areas which are most suitable to him/her and suggests the next **three** exercises the student has to practice according to his/her current level of knowledge. Also if the student does not want to follow the topic that the system suggests, he/she can go to the Exercise selection page shown in Figure 4.6 and select exercises under any other topic.
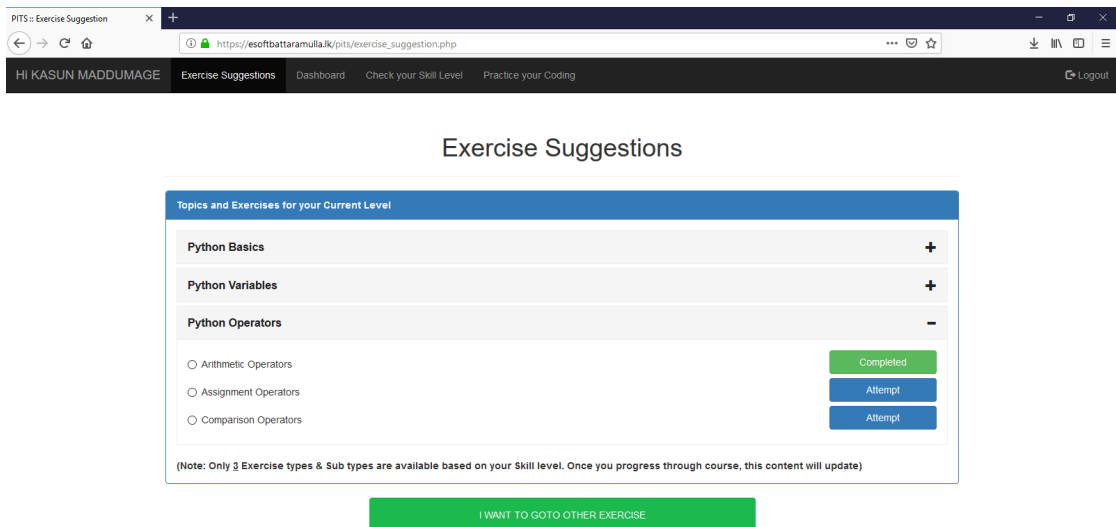
Figure 4.5 : Exercise Suggestions Page

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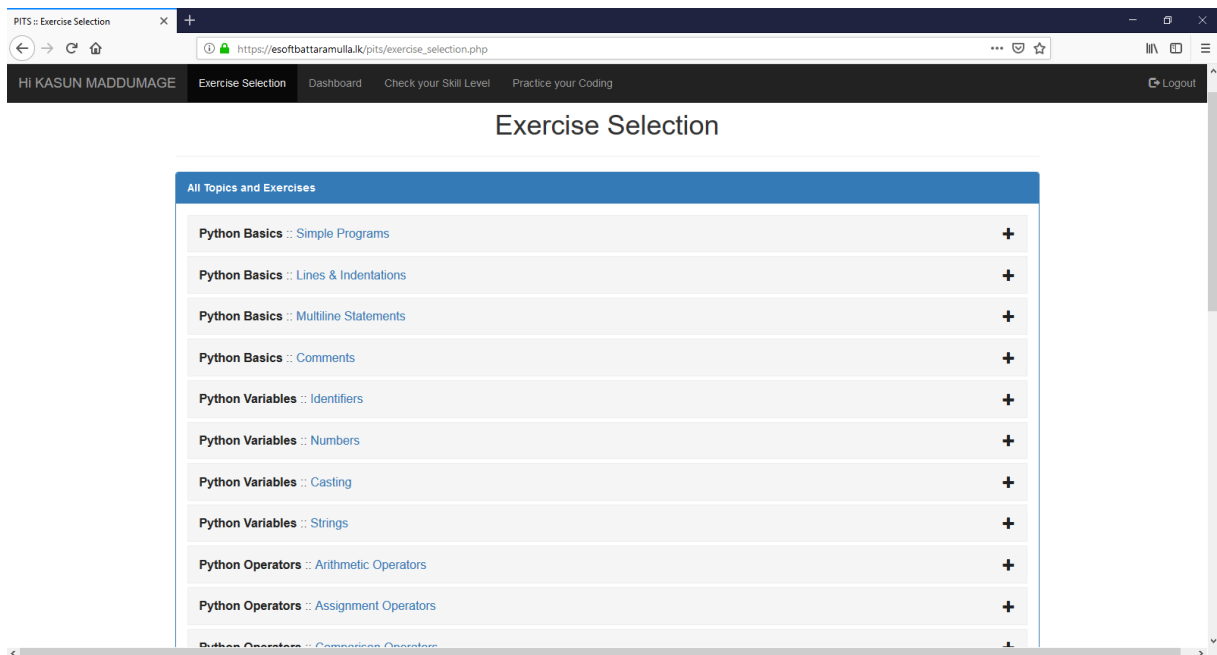
Figure 4.6 : Exercise Selection Page

Next major component of the PITS is exercise suggestion page logic. Following code modules will be used during the process of exercise suggestion and selection of individual learner. Files used for that process is labeled as ***exercise_suggestion.php*** and ***exercise_selection.php***. Both pages use similar presentation and code logic so only exercise suggestion code modules are included as a reference. Note that students are allowed to attempt their exercises only after completing **2hrs** of practice coding sessions using the code blocks provided as supportive materials. Code modules related to practice page are included in the ***practice.php*** and ***practice_process.php*** scripts.

exercise_suggestion.php

```
<div class="form-group">
        <div class="panel panel-primary">
                <div class="panel-heading"><b>Topics and Exercises for your Current Level</b></div>
                        <div class="panel-body">
                                <div class="panel-group" id="accordion">

<?php
        $sqlT = "SELECT DISTINCT S.QuestionType AS TID, T.QuestionType AS Type FROM tblSkillLevels S, tblQuestionTypes T WHERE UID='".$_SESSION['uid']."' AND T.QuestionTypeID=S.QuestionType AND SkillLevel<100 ORDER BY T.QuestionTypeID LIMIT 3";
        $resultT = $con->query($sqlT);

        if ($resultT->num_rows == 0)
        {
                // No question types
```

```php
		}
		else
		{
			$ls=0;
			$tab = 1;

			while($rowT = $resultT->fetch_assoc())
			{
?>
				<div class="panel panel-default">
					<div class="panel-heading">
						<h4 class="panel-title">
							<a role="button" data-toggle="collapse" data-parent="#accordion" href="#<?=$rowT['TID'];?>"><i class="more-less glyphicon glyphicon-plus"></i><?="<b>".$rowT['Type']."</b>";?></a>

						</h4>
					</div>
					<div id="<?=$rowT['TID'];?>" class="panel-collapse collapse">
						<div class="panel-body">
							<?php
							$sqlST = "SELECT S.QuestionSubType AS STID, ST.QuestionSubType AS SubType FROM tblSkillLevels S, tblQuestionSubTypes ST WHERE UID='".$_SESSION['uid']."' AND (ST.QuestionSubTypeID=S.QuestionSubType AND ST.QuestionTypeID=S.QuestionType AND S.QuestionType='".$rowT['TID']."') AND SkillLevel<100 ORDER BY ST.QuestionSubTypeID ASC LIMIT 3";
							$resultST = $con->query($sqlST);

							if ($resultST->num_rows == 0)
							{
								// No question sub types
							}
							else
							{
								while($rowST = $resultST->fetch_assoc())
								{
?>
								<div class="row">
									<div class="col-sm-10">
										<div class="radio">
											<label>

		<input type="radio" id="QType<?=$ls.$rowT['TID'].$rowST['STID'];?>" name="QType" value="<?=$rowT['TID'].'||'.$rowST['STID'];?>" tabindex="<?=$tab++;?>" />
```

```php
        <?=$rowST['SubType'];?>
                                                                </label>
                                                              </div>
                                                    </div>
                                                    <div    class="col-
sm-2">
                                    <?php
                                                    //    button
gernerating logic
                                                    $noOfEx  =
0;
                                                    $sqlC    =
"SELECT    COUNT(ExerciseID)  AS    EC    FROM    tblExercises    WHERE
QuestionType='".$rowT['TID']."' AND QuestionSubType='".$rowST['STID']."'";
                                                    $resultC  =
$con->query($sqlC);

                                                    if
($resultC->num_rows == 0)
                                                    {
                                                          //
No exercises
                                                    }
                                                    else
                                                    {

    $rowC = $resultC->fetch_assoc();

    $noOfEx = $rowC['EC'];

                                                    }


                                                    $noOfPEx
= 0;
                                                    $sqlCC    =
"SELECT COUNT(A.Exercise) AS PEC FROM tblExercises E, tblExerciseStudAttempts A
WHERE    UID='".$_SESSION['uid']."'    AND    A.Exercise=E.ExerciseID    AND
QuestionType='".$rowT['TID']."'  AND  QuestionSubType='".$rowST['STID']."'  AND
CompletedStatus='Y'";
                                                    $resultCC
= $con->query($sqlCC);

                                                    if
($resultCC->num_rows == 0)
                                                    {
                                                          //
No completed exercises
                                                    }
                                                    else
                                                    {
```
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```php
        $rowCC = $resultCC->fetch_assoc();

        $noOfPEx = $rowCC['PEC'];
                                                                }


        if(($noOfEx != 0 && $noOfPEx != 0) && $noOfEx === $noOfPEx)
                                                                {
                                        ?>
                                                                <button
type="button"                  class="btn              btn-success          btn-block"
tabindex="<?=$tab++;?>">Completed</button>
                                                        <?php


                                                                }
                                                                else
                                                                {
                                        ?>
                                                                <button
type="button"
onclick="checkNSubmit(frmSuggestion.QType<?=$ls.$rowT['TID'].$rowST['STID'];?>,
frmSuggestion);"              class="btn          btn-primary          btn-block"
tabindex="<?=$tab++;?>">Attempt</button>
                                                        <?php


                                                                }
                                        ?>
                                                        </div>

                                                </div>

                                <?php
                                        }
                                   }
                                ?>
                        </div>
                    </div>
                </div>
<?php
                $ls++;
            }
        }
?>
                </div>
                <b>(Note: Only <u>3</u> Exercise types & Sub types are available
based on your Skill level. Once you progress through course, this content will update)</b>
            </div>
        </div>
</div>
```

Below Figure 4.7 shows the sample code blocks given for practice sessions in Practice page.

Figure 4.7 : Practice Page

From those suggestions or selections page student can select an exercise and then student will be directed to the Exercise Answer page which is shown in Figure 4.8.

The question of the selected exercise is displayed on the top area of the page. Under the question, an area is provided for the student to enter the answer. On the right hand side to the answer area there is a button panel. Student can click on **Check My Answer** button after entering the answer to check the errors of the answer. Then the system analyses the student's answer for errors.

Within the analysis if any syntax error being identified, it will be displayed by highlighting the position of the syntax error. Also the error message and the feedback on the error are displayed in the feedback area of the bottom of the page. If no syntax errors are found the analysis continues to check for logical errors. If any logical errors are found, error message is displayed in the feedback area along with the feedback. Student can correct errors in the answer and again click on the **Check My Answer** button to evaluate the answer. In this case based on the complexity an impossibility of checking the logical errors of the student answer, new concept is implemented to show **code tokens** related to a specific exercise.
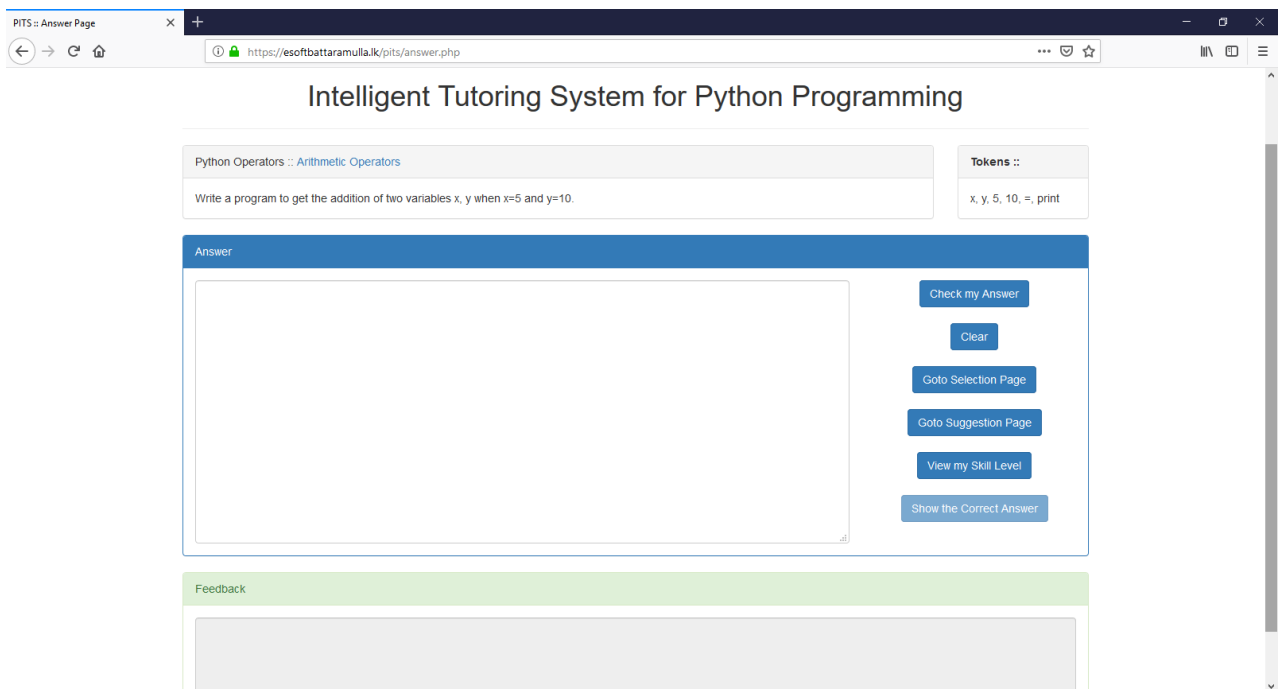
Figure 4.8 : Exercise Answering Page

Also student have the option to click on **Show the Correct Answer** button to view the correct solution for the question. **Clear** button is to erase everything in the answer area and restart coding from the beginning.

Go to Selection Page and **Go to Suggestions Page** buttons are there for the student to select another exercise if they want to leave the current exercise and go for another exercise.

There is **View My Skill Level** button for the student to check the current knowledge level that he/she achieved. The Skill Level page is shown in Figure 4.9. It contains the entire list of question types that are covered by the tutor and the competence level that the student achieved in each type.
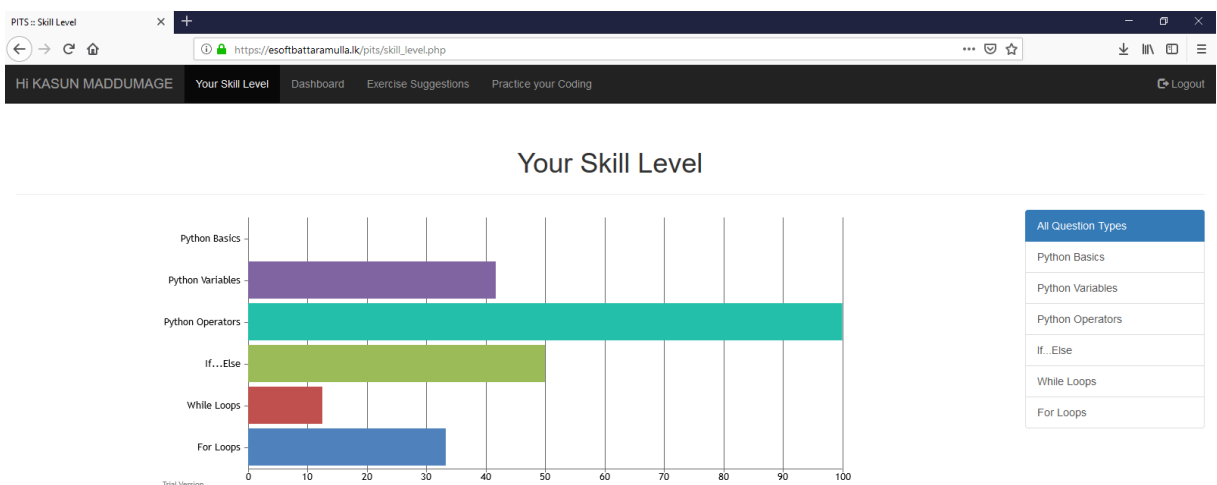
Figure 4.9 : Skill Level Page

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Following code block is used to generate the graph using CanvasJS 3rd party component. And source code related to the section are included in ***skill_level.php*** script.

<u>skill_level.php</u>

```php
<script>
window.onload = function () {

var chart = new CanvasJS.Chart("chartContainer", {
        animationEnabled: true,
        title: {
                //text: "Student Skill Level"
        },
        axisX: {
                interval: 1
        },
        axisY: {
                maximum: 100,
                interval: 10
        },
        data: [{
                type: "bar",
                dataPoints: [
                        <?php
                                if(isset($_GET['t']) && !empty($_GET['t']))
                                {
                                        $sql = "SELECT T.QuestionSubType AS
QuestionType, SkillLevel AS SL FROM tblQuestionSubTypes T, tblSkillLevels S WHERE
S.QuestionType=T.QuestionTypeID AND S.QuestionSubType=T.QuestionSubTypeID AND
T.QuestionTypeID='".$_GET['t']."' AND UID='".$_SESSION['uid']."' ORDER BY
T.QuestionTypeID DESC";
                                }
                                else
                                {
                                        $sql = "SELECT T.QuestionType, SUM(SkillLevel) AS
SL FROM tblQuestionTypes T, tblSkillLevels S WHERE
S.QuestionType=T.QuestionTypeID AND UID='".$_SESSION['uid']."' GROUP BY
T.QuestionTypeID ORDER BY T.QuestionTypeID DESC";
                                }
                                $result = $con->query($sql);

                                if ($result->num_rows == 0)
                                {
                                        // No questions
                                }
                                else
                                {
                                        while($row = $result->fetch_assoc())
                                        {
                        ?>
                        { label: "<?=$row['QuestionType'];?>", y: <?=$row['SL'];?> },
```

```php
                        <?php
                                }
                        }
                ?>
            ]
        }]
});
chart.render();

}
</script>

 <div class="list-group">
        <a href="skill_level.php" class="list-group-item list-group-item-
action<?=((!isset($_GET['t']) && empty($_GET['t'])) ? ' active disabled' : '');?>">All
Question Types</a>
        <?php
                $sqlT = "SELECT QuestionTypeID, QuestionType FROM tblQuestionTypes";
                $resultT = $con->query($sqlT);

                if ($resultT->num_rows == 0)
                {
                        // No questions
                }
                else
                {
                        while($rowT = $resultT->fetch_assoc())
                        {
        ?>
        <a href="skill_level.php?t=<?=$rowT['QuestionTypeID'];?>" class="list-group-item
list-group-item-action<?=((isset($_GET['t']) && !empty($_GET['t'] && $_GET['t'] ==
$rowT['QuestionTypeID'])) ? ' active disabled' : '');?>"><?=$rowT['QuestionType'];?></a>
        <?php
                        }
                }
        ?>
</div>
```

Finally as the entire research is based on providing the most appropriate feedback to the students, following custom code block is used for that purpose. And source code related to the section are included in *answer.php* and *answer_process.php* scripts and all DB tables are updated accordingly. It also inject relevant data to manipulate entries in the Top Performers section in the homepage. Student provided answer will be used by code logic and will put into a python (.py) file and will be executed using the PHP script. Even Python IDLE is not developed to capture all errors at once, this custom code is capable of handling the code segments as statements and blocks. It will run the given code and will return errors and

important feedback generated by the logic to the student in a differently formatted presentable notation.

answer_process.php

```php
include_once('blocks.php');
$_SESSION['ans'] = '';
$_SESSION['fb'] = '';
if(isset($_POST['txtCode']) && !empty($_POST['txtCode']))
{
        $_SESSION['ans'] = trim($_POST['txtCode']);
        // writing some text files
        $myFile = fopen($_SESSION['uid']."_test.py", "w");
        $txt = "f = open('".$_SESSION['uid']."_code.py', 'r')\n";
        fwrite($myFile, $txt);
        $txt = "code_str = f.read()\n";
        fwrite($myFile, $txt);
        $txt = "f.close()\n";
        fwrite($myFile, $txt);
        $txt = "code = compile(code_str, '".$_SESSION['uid']."_code.py', 'exec')\n";
        fwrite($myFile, $txt);
        $txt = "exec(code)\n";
        fwrite($myFile, $txt);
        fclose($myFile);

        $text = trim($_POST['txtCode']);
        $text = str_replace("\n", "*", $text);
        $textArr = explode("*", $text);//print_r($textArr);exit;

        $line = 1;
        $errArr = array();
        foreach ($textArr as $stmt)
        {
                // processing here...
                if ((strpos($stmt,'if ') !== false) || (strpos($stmt,'else') !== false) ||
(strpos($stmt,'for ') !== false) || (strpos($stmt,'while ') !== false))
                {
                        $indent = 'Y';
                }
                else
                {
                        if(isset($indent) && $indent == 'Y' && strspn($stmt, "\t") >=1)
                        {
                                $stmt = trim($stmt);
                        }
                }

                if($stmt != "")
                {
                        //echo ">>>>".$stmt."<br />";
```

```php
                         file_put_contents($_SESSION['uid']."_code.py", $stmt);
                         $output = shell_exec($_SESSION['uid'].'_test.py >
'.$_SESSION['uid'].'_debug.log 2>&1');

                         $file = file_get_contents($_SESSION['uid'].'_debug.log');
                         if (strpos($file,'SyntaxError:') !== false)
                         {
                                 //echo $file;exit;
                                 $fileArr = explode("\n", $file);
                                 $lastIndex = count($fileArr)-1;
                                 unset($fileArr[0]);
                                 unset($fileArr[1]);
                                 unset($fileArr[2]);
                                 unset($fileArr[3]);
                                 unset($fileArr[$lastIndex]);
                                 //print_r($fileArr);exit;
                                 $file = implode("\n", $fileArr);
                                 if (strpos($file,'else:') !== false)
                                 {
                                         $fileArr = explode("\n", $file);
                                         if(trim($fileArr[0]) == 'else:' && trim($fileArr[1]) ==
'^')
                                         {
                                                 $line++;
                                                 continue;
                                         }
                                 }
                                 $errArr[$line] = $file;
                         }
                 }
                 //echo $line;
                 $line++;
        }
        //print_r($errArr);
        //$errLablels = implode('|', $errArr);
        //$strMatch = array( '\n', '\n\r', ' ' );
        //$errLablels = str_replace($strMatch, '|', $errLablels);

        $keywords = array();
        $msgArr = array();
        foreach ($errArr as $ek=>$ev)
        {
                //$msgArr[] = 'Line ' . $ek . ' : \n<pre>' . $ev . "</pre>";
                $msgArr[] = 'Line ' . $ek . " : \n" . $ev;
                $evParts = explode('^', $ev);
                if(strpos($evParts[0], 'print') !== false)
                {
                        $keywords[] = 'print';
                }
                if(strpos($evParts[0], 'input') !== false)
                {
                        $keywords[] = 'input';
```

```
            }
            if(strpos($evParts[0], 'if') !== false || strpos($evParts[0], 'else') !== false ||
strpos($evParts[0], 'elif') !== false)
            {
                    $keywords[] = 'if';
            }
            if(strpos($evParts[0], 'while') !== false)
            {
                    $keywords[] = 'while';
            }
            if(strpos($evParts[0], 'for') !== false)
            {
                    $keywords[] = 'for';
            }
    }
    //print_r($keywords);

    $errors = '';
    $errors = implode("\n\r\n\r", $msgArr);
    //echo $errors;

    $feedbackArr = array();
    foreach($arrBlocks as $string)
    {
            foreach($keywords as $keyword)
            {
                    if(is_array($string))
                    {
                            foreach($string as $s)
                            {
                                    if(is_array($s))
                                    {
                                            foreach($s as $ss)
                                            {
                                                    if(strpos($ss, $keyword) !== false)
                                                    {
                                                            $feedbackArr[] = $ss;
                                                    }
                                            }
                                    }
                                    else
                                    {
                                            if(strpos($s, $keyword) !== false)
                                            {
                                                    $feedbackArr[] = $s;
                                            }
                                    }
                            }
                    }
                    else
                    {
                            if(strpos($string, $keyword) !== false)
```

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```php
                                {
                                        $feedbackArr[] = $string;
                                }
                        }
                }
        }

        $feedback = '';
        if(trim($errors) != '')
        {
                $feedback = implode("\n", $feedbackArr);
                $_SESSION['fb'] = $errors . "\n\rSuggestions::\n==========\n" .
$feedback;
                header("Location: answer.php?f=e&eid=".$_POST['eid']."#ans");
        }
        else
        {
                file_put_contents($_SESSION['uid']."_code.py", trim($_POST['txtCode']));
                $output = shell_exec($_SESSION['uid'].'_test.py >
'.$_SESSION['uid'].'_debug.log 2>&1');
                $file = file_get_contents($_SESSION['uid'].'_debug.log');
                $feedback = $file;
                $_SESSION['fb'] = "Output::\n======\n" . $feedback;
                header("Location: answer.php?f=s&eid=".$_POST['eid']."#ans");
        }
        //echo $feedback;
}
```

Above code block only present the logic behind separating and executing student specific unique code blocks by the server and how the messages (error/feedback) are constructed to present to the individual learners. Following Figure 4.10 and Figure 4.11 shows how the final presentation of feedback is shown to the specific student. The two colour schemes success and danger are used in this situation to provide necessary level of attention to the feedback that they get after checking their answer for an exercise question. When providing the feedback during errors in the student answer it will use the *blocks.php* include file to provide suggestions to improve their answer containing error(s). Each error line number and the most possible cause will be displayed in the feedback area. The feedback is presented to the specific student by using their subject teachers' profile. To make the feeling of student-teacher interactions while these exercises specific teachers' image will be shown with a pop up message. Which gives the mentality that their participating for an activity far more similar to a classroom based activity. Attempts are maintained during each answering session and students are monitored against their performance and based on their achievements some additional encouragement is provided while putting their names under "Top Performers" section in homepage.
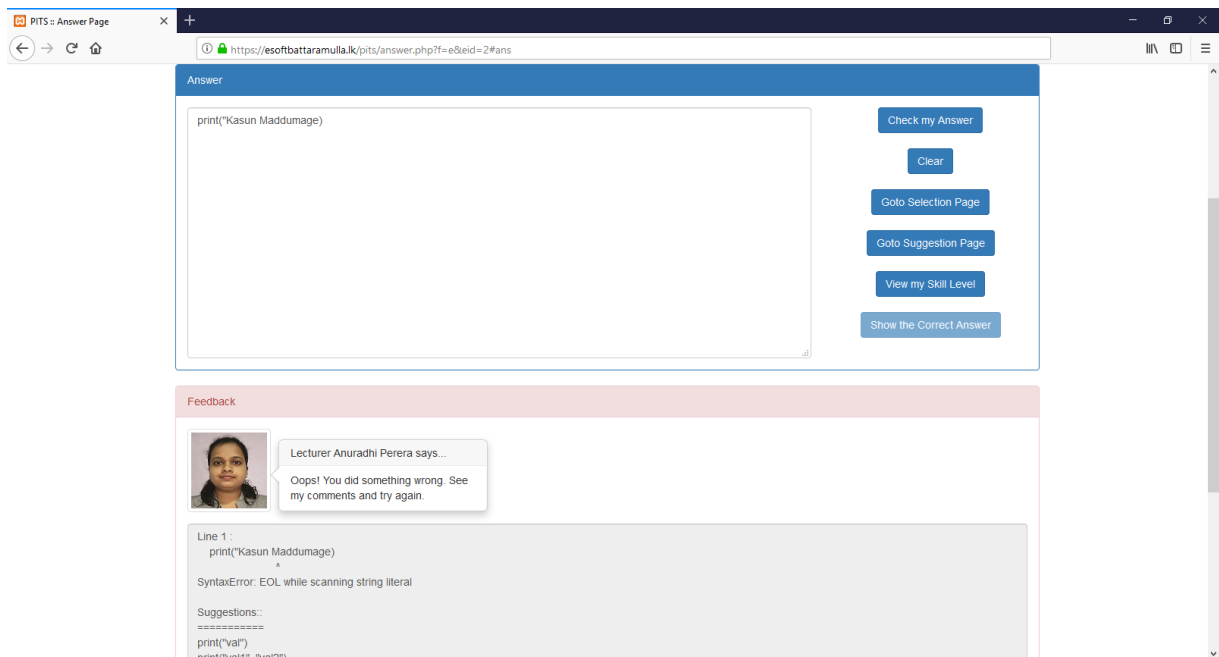
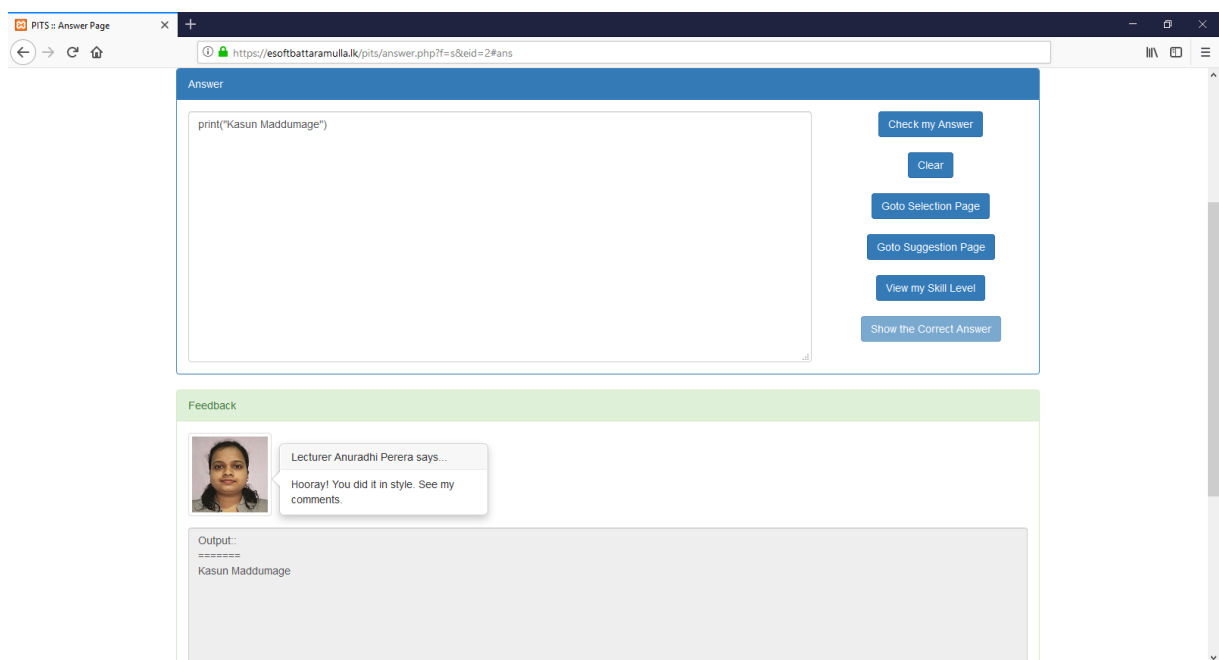Figure 4.10 : Student Exercise Feedback with Errors

Figure 4.11 : Student Exercise Feedback without Errors

Additional details related to implementation and system help are included in the Appendix E: User Manual section. Only most important functionalities and code segments are included in the above sections. Next chapter explains the approach used to evaluate the implemented PITS. Note that only standard Bootstrap components were used for the development. Some of the main components which are used during implementation are Modal, Panel, Grids, Popover, Alerts, List groups, Navbar, Forms, Collapse and etc.

CHAPTER 5 : EVALUATION

This chapter describes how the Intelligent Tutoring System was evaluated to check whether it has achieved its aims and objectives. Alone with the evaluation process testing strategy of the proposed ITS also attached in this chapter. Testing the appropriateness of the solution to the addressed problems is also covered as a part of this section. Apart from the basic level of verification and validation will not be enough for a research based project. It must ensure the suitability of solution based on statistical analysis of results obtained after conducting the evaluation. Evaluation performs a critical level of post-mortem to ensure that the system meets its desired goals.

Out from the various evaluation techniques available in the literature, selecting the best option to conduct an in-depth evaluation to the developed system are also included in the below sections. Section 5.1 describes how the evaluation process is planned and the selection of participants to the evaluation. Section 5.2 gives the results of the evaluation after conducting the picked evaluation technique.

5.1   EVALUATION PROCESS

After conducting study about the evaluation techniques available in the industry, both Experimental based and Opinion & Interview based evaluation approaches are picked to conduct the evaluation of the research project. Combination of those two techniques improves the evidence of the suitability of the developed solution. Using both methods overcome the limitations of each method. Because experimental evaluation is focused on quantitative data and opinion & interview evaluation is focused on qualitative data. As the research is also done based on user inspired and applied approach evaluation has to be conducted in both ways to ensure system achieve its functionalities in the acceptable level. Those two approaches help to gain deeper understanding how useful and the level of satisfaction by the system users for the desired purpose. The support on which enhance the learner experience also judged based on the evaluation results. It also provide a pathway to check the system accessibility and usability against the performance, it helps to conduct further research based on the outcome of the evaluation process. Picking the best approach is done during the initial analysis and planning stage of the project and are used during the evaluation process with pre-set test cases and test data. It is useful when conducting sufficient level of testing without doing it in an ad-hoc manner.

In addition to the above two techniques the evaluation process has planned to be done using empirical methods too, which use both qualitative and quantitative evaluation to assess following aspects.

- Level of achievement of pedagogical practices by the system.
- Improvement to student knowledge in Python after using the system.
- The efficiency, accessibility and usability of the system.
- The appropriateness of the lessons according to the students' knowledge level.
- Effectiveness of the feedback given to the student and whether students are able to get the real understanding about the feedback that they received from the system.

It was planned to get five types of participants for the evaluation process.

- Python Teachers
- Undergraduate Students
- HND Students
- Diploma in IT Students
- A/L ICT Students

The purpose to participate teachers for the evaluation is they can assess the system using teaching perspective which will give us a good feedback about teaching methodology used by the system and the efficiency, usability of the system. Python teachers can go through the internal logic of the system to evaluate the quality of the system. Also those teachers should have experience in teaching Python Programming.

Also by using five groups we can get five knowledge levelled participants to the evaluation. Both Undergraduate and HND students have basic knowledge in python programming. Generally Diploma and A/L ICT students have no prior experience in programming using python. Following Table 9 shows the participants counts for evaluation process. Participants were picked from the ongoing batches running during that period at the institute. Students are picked with mind set on the results obtained during learner analysis too. Because some students show a real enthusiasm of experiencing such an ITS system. The developed platform is available for learners under https://www.esoftbattaramulla.lk/pits/ domain.

Table 7 : Participant Counts Involved in Evaluation Process

Participants Category	Head Count
Python Teachers	03
Undergraduate Students	05
HND Students	12
Diploma Students	25
A/L ICT Students	05
Total Participants	**50**

There were 50 participants were collected to conduct a sound level of evaluation of the newly implemented ITS for python programming. Three teachers were selected for the evaluation by an open invitation. For the teachers group, the system has been directly given to use for 2 weeks for the evaluation. For all participants a questionnaire has given to get the feedback and result of their assessing. The questionnaire is included Appendix D.

Evaluation results were collected in two stages. First students were given same set of questions and are asked to provide answers for those questions in a physical classroom environment after providing a classroom based lecturing session and results were documented. Then same set of students were given the opportunity to use and experience the ITS which is newly developed, then they were ask to provide answers for the exercises given in the platform and the results were separately logged. To get quantitative results and to forward the evaluation based on quantitative form those to result sets were compared against certain criteria. The main criteria that were considered before concluding the final decision are;

- Time that each students spent on the ITS practice sessions
- Marks obtained by each student during the physical evaluation exercises
- Progression of the python course and knowledge based on the feedback
- Impact made to the performance based on rewarding by the teachers
- Impact made by collaboration and peer support
- Impact on repeating mistakes for exercise results
- Impact on different categories of students by using the ITS
- Impact on using effective HCI features for easy delivery of feedback into desired level
- Etc.

Apart from the evaluation conducted using the above specified techniques, standard testing and debugging process is followed alone with the development stages. Developed functional units were tested against the carefully selected test data to ensure all functional units are working without any syntactical and logical errors. Whenever a bug is located necessary actions were made to correct those issues. So during the development unit testing, integration testing was conducted to ensure all modules are working according to the initial plan and specification. Verification and validation are two other mechanisms which are used to guarantee that developed system meets its specification.

5.2 EVALUATION DATA SETS

Sample exercises are included after studying the basic course content available in python courses for those various courses offered at the institute. As Multiple Choice Question (MCQ) are not suitable for testing the students real problem solving ability questions were formulated by having the mind set to provide the answers in the form of program code blocks. Results gathered by those testing and evaluation sessions are attached in the below section. Test data sets are purely designed based on the syllabus content of those python courses. Almost all course cover basic level of content in each course it did not make any complications when preparing the exercises and evaluation procedure. All the materials, course content and evaluation exercises were added into the following test location for people to experience. So the individual participants can experience and provide the feedback at their convenient intervals.

As the system was given to the users to experience their user experience and feedback was gathered and documents as an evidence to show up to what extend the developed system is useful in the nature of problem of learning python programming without the intervention of human teachers.

Continues feedback gathered after each cycle of user experience system was remodified in order to make it fulfill the needs of the learners based on their metal model. The evaluation results prove that the acceptance of the solution by its audience.

Following are the testing areas which are highly focused in the evaluation process. And the assessments are created by mixing one or more of the following areas. Same set of questions are produced as hardcopy printouts and given for answering with a pen and paper after giving a soft training on the relevant section of study. But for physical evaluation python teachers are excluded. The main areas which are focused to be included and evaluated are;

- Working with print function

- Working with input function and type conversion

- Working with variables

- Working with basic operators (arithmetic, assignment, comparison, etc)

- Working with if conditions

- Working with loops

- Working with comments

- Etc.

5.3   EVALUATION RESULTS

Questionnaire has been given to all the participants who have participated for the evaluation process. User responses to the feedback questionnaire were used to generate following graphs to get an idea about the ratings given for the system.
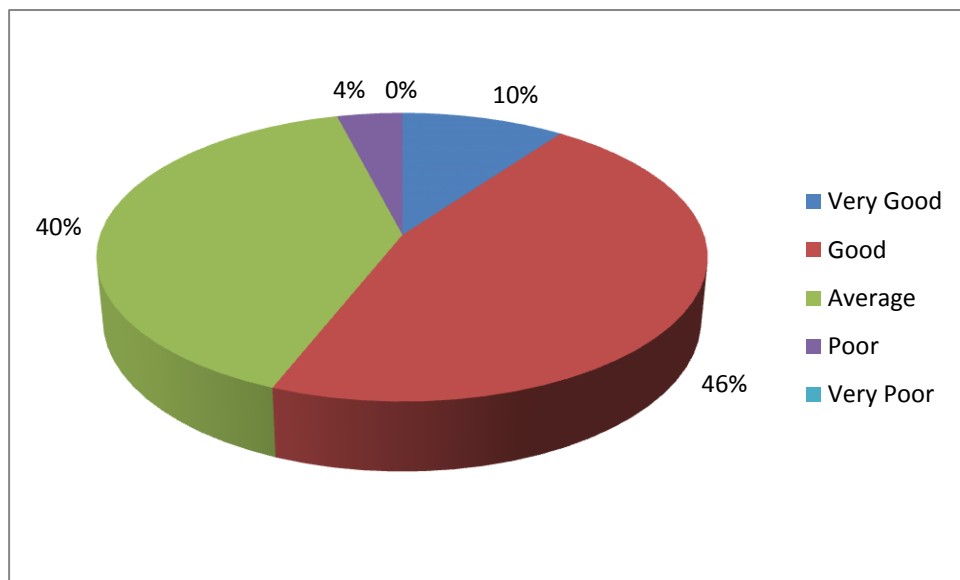

Figure 5.1 : User Interfaces of the System

Figure 5.1 shows how the users rated about the user interfaces of the system. 10% rated as it is very good. Majority has selected it as good and average. 4% rated as poor but no ratings for very poor. So it can be decided majority of the users a happy with the user interfaces of the system and how the functionalities are presented for the learners in its best form to cater for the needs of the learners. It confirms the HCI principals which are used for functional areas are up to the easy accessible level so any knowledge level users are able to gain the expected use of the developed ITS.

Another aspect that has given for users to rate is usability of the system. Figure 5.2 shows the ratings given for it. Majority has given good and average while 12% giving very good for Usability. No one thinks the system in poor or very poor in this criterion. Any system which is developed must be usable as well as accessible, so systems users need not to put additional effort to use and experience the given tool.
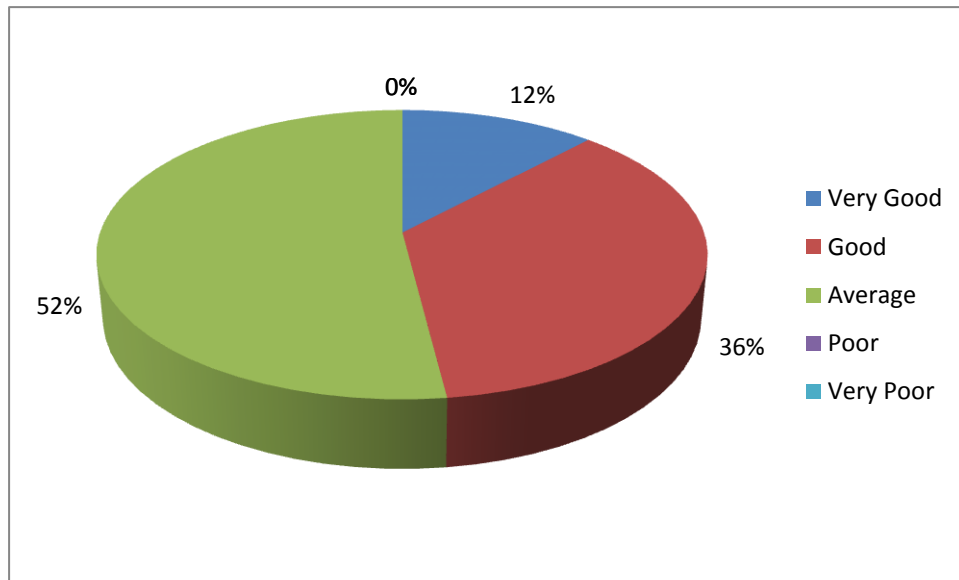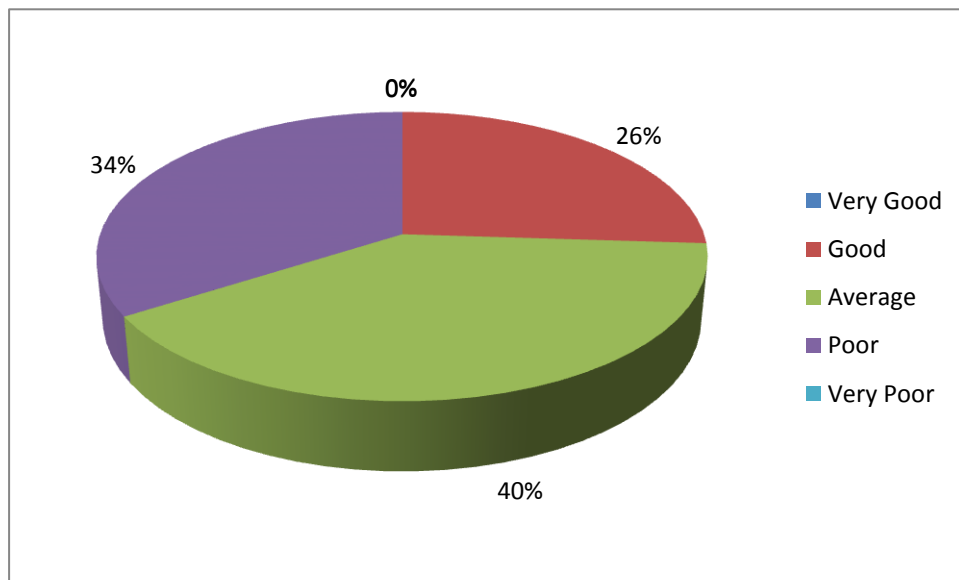

Figure 5.2 : Usability of the System

Figure 5.3 : Programming Exercises

Figure 5.3 shows the ratings about quality of the programming exercises given by the system. None says it is very good and 26% of users say that it is good. 40% thinks those are in

average quality and 34% says poor. Reason they have given for this result was that the enough amount of programming concepts are not implemented in the system as their textbooks may cover additional areas, content and exercises than available in the developed platform.

One of the main functionalities in the Python Intelligent Tutor is exercise selection. Figure 5.4 demonstrate the user rates given to the exercise selection capability. 60% thinks it is in average level while 36% thinks it is in good or very good level. Also 4% rated as poor but none rated very poor.
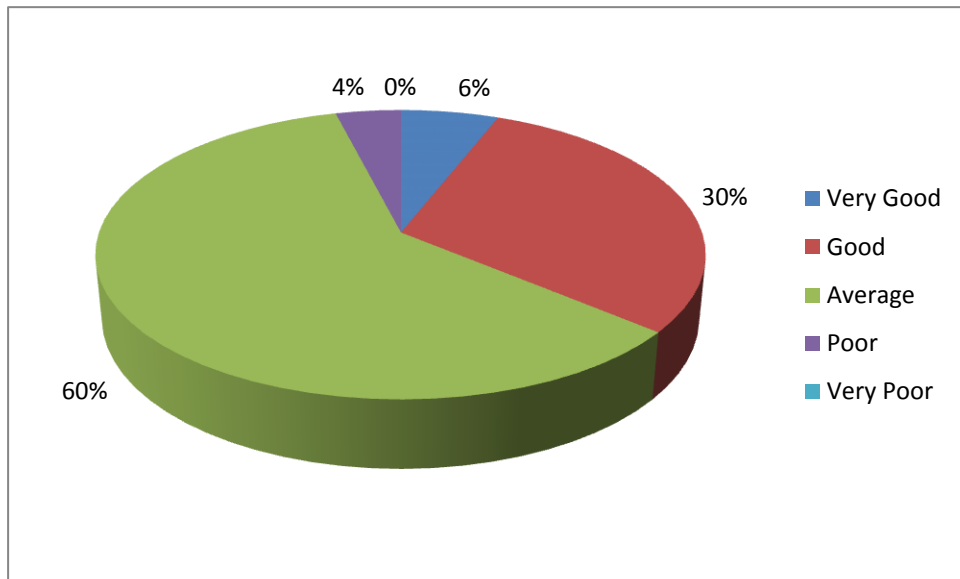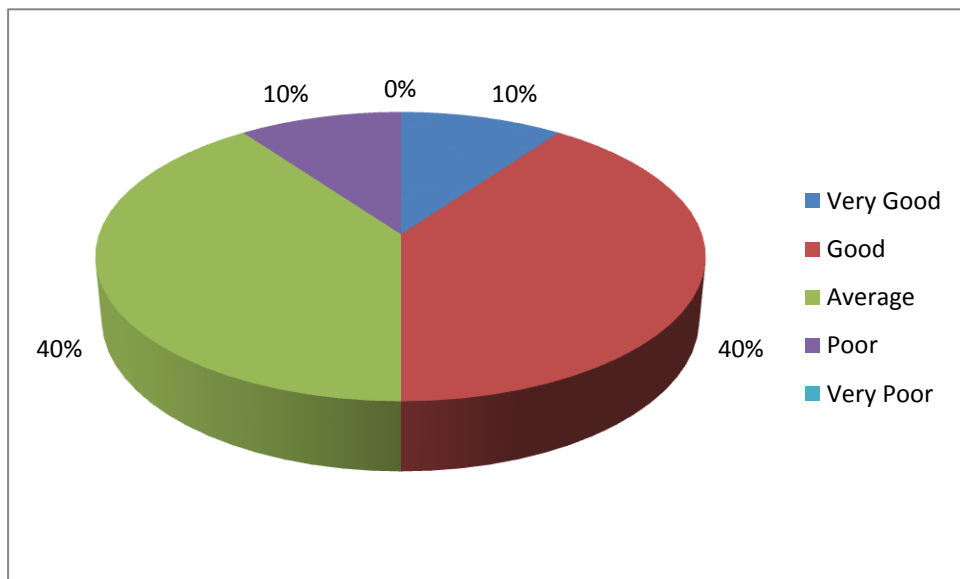

Figure 5.4 : Exercise Selection

Figure 5.5 : Quality of Feedback Messages

Figure 5.5 represents the ratings of quality of feedback messages while Figure 5.6 shows the ratings for success in improving Python knowledge by using the system. In both criteria majority (more than 70%) rates them as good or average and none thinks those features are in very poor level. The main purpose of this research project is to provide personalize feedback on the activities and exercises that they do on top of this platform, so the obtained results prove that most of them highlighted the developed system is capable of handling the main requirement of an ITS.
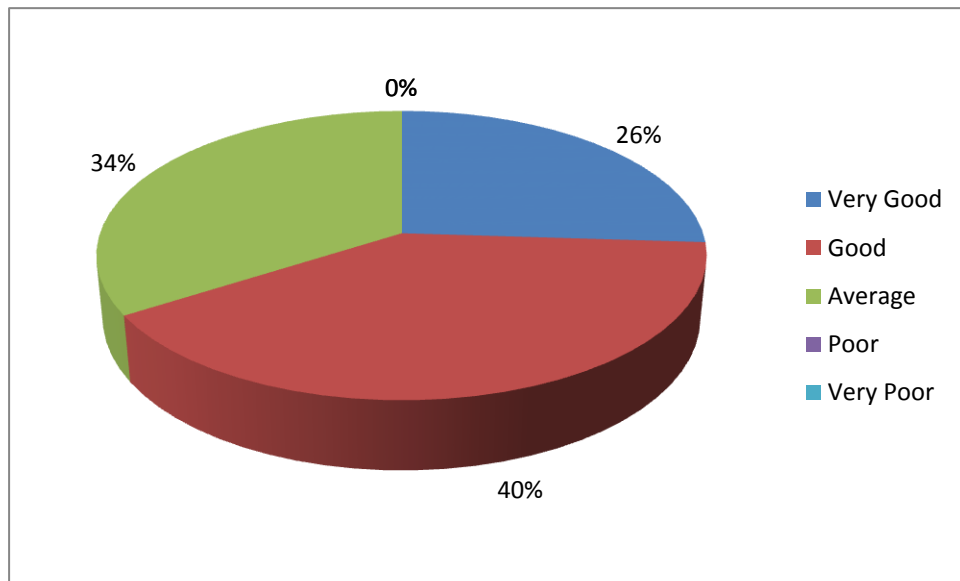

Figure 5.6 : Success in Improving Python Knowledge

Ratings for the overall impression for the system are shown in Figure 5.7. Total of 8% says it is very good and 70% felt that the system is good. None thinks that it is poor or very poor. So it can be concluded that majority of the users are satisfied with the system.
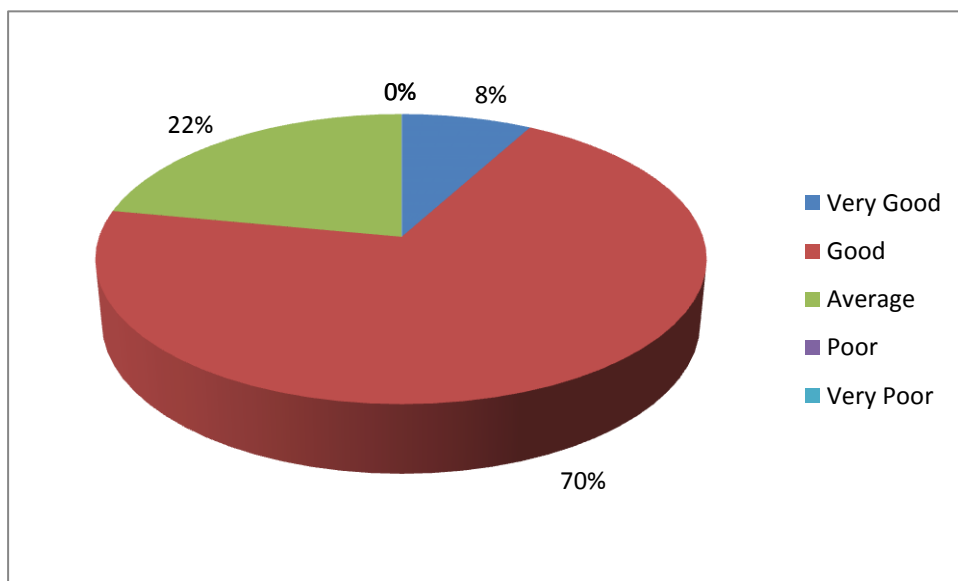

Figure 5.7 : Overall Impression about the System

The responses given to the free-questions in the questionnaire provide details to the improvement of the system.

Those free-questions were used to evaluate the accuracy of the identification of knowledge level of the student, appropriateness of the lesson and exercise selection, correctness of the given solution identification and how helpful the personalized feedback to improve their interactive learning with the given platform for python programming.

Eg:

- Did the feedback provided by the system was helpful to understand errors?
- What do you feel about the Exercise Suggestions of the system? Are they appropriate?
- Did the system analyze the answers correctly?
- Does the system identify your knowledge level accurately?
- Did the system use the concepts use by a subject teacher like in a physical classroom based learning?
- Is the system is usable and accessible in all sort of forms?

Some users commented that the systems should provide theoretical instructions for the lessons without only directing students to do exercises. So as a result on that system is re-aligned with a facility for practicing the same activities and exercises given in the textbooks. Drag and drop code modules were introduced while facing for practice session, encourage students to visually see and memorizing the important code segments in python programming. Some suggested ideas for improving user interfaces with more features and feedback messages. Many responded that they will suggest the completely developed system to the students to improve Python knowledge.

Overall summery of comments shows that the system has positive attributes to improve students' knowledge in Python programming. Following Table 10 illustrated the actual statistics of the results obtain while conducting the evaluation process and are used as the next level of input to do further level of improvements to the developed platform. It was noted that the rewarding mechanism which is developed helped a lot to encourage learners in a competitive manner. So the learners became more active while participating for the learning sessions so they put their maximum to get the best out of the implemented platform for their learning needs. Even students who scored lower score for their initial exercises were highly motivated while they progress through the course.

As numerical figures are useful to get the real understanding on how the developed system is up to the expected standard, the following comparison will be beneficial.

Table 8 : Statistical Data of Evaluation Process Based on Participant Feedbacks

Participants Category	Very Good	Good	Average	Poor	Very Poor
User Interfaces of the System	5	23	20	2	0
Usability of the System	6	18	26	0	0
Quality of Exercises Given by the System	0	13	20	17	0
Exercise Selection Mechanism by the System	3	15	30	2	0
Appropriateness of Feedback Given by the System	5	20	20	5	0
Help on Improving Python Knowledge Level Using the System	13	20	17	0	0
Overall Impression About the System	4	35	11	0	0
Total Participants	50				

All the above mentioned graphs were plotted using the data abstracted from the above table. And those results are gathered after getting the feedback by filling the feedback form by the users of the implemented system.

Final conclusion of the evaluation process is, the platform which is developed for the aim of catering python learning student population in the institute, majority of them are satisfied with the solution that they get. Most of the people believe that it did a big impact on their final grade achieved in their final examination conducted after the course time. But still there are some more valuable thoughts were gathered and are able to solve in the due course.

CHAPTER 6 : CONCLUSION

This chapter includes a summary of the work that has been carried out during the project, problems encountered within the project. It also covers the untouched areas of the developed ITS and the future enhancements which can be done in this development. This section cited whether the implemented system will be able to find the solution to the conducted research. Any short comes caused on functionalities due to technical barriers are also included as part of this chapter.

This project was aimed to develop a versatile Intelligent Tutoring System to teach Python programming. In particular, a research has been carried out on other ITS which teaches programming & methods of teaching programming to beginners and all levels of learners. As described in section 1.4 Research Questions, the project work targeted on following research questions and research discipline.

1. *How to construct the most accurate feedback related to students activities in Intelligent Tutoring System?*

This is the main achievement of this research. Python Intelligent Tutoring System is capable of analysing providing the desired feedback related to a student activity take place during a particular exercise. It uses artificial intelligence, pedagogical and cognitive theories for that purpose. Python ITS provides customized feedback regarding errors. Also it provides additional examples for the students to learn from that. Therefore the first research question is answered and a solution is achieved during this project.

2. *What is the most efficient way of presenting the constructed feedback to maximise learning experience of students?*

As students are dealing with a computer based solution they must feel the same comfort while they are facing the exercise sessions. How teachers describe and present the feedback on a normal classroom activities are automated in a web based system alone with the most appropriate HCI concepts. It helps the students who sit for the course using this solution get the same support from the tool like a subject teacher does in the manual phase. So it can be concluded that second research question is also answered by the project.

*3. **What is the best method to measure the student's knowledge level?***

The system divides the subject content in to a set of knowledge components and maintains students' competency level for each component. At each exercise, it updates the relevant knowledge components. Based on those levels system suggests suitable exercise for the student to his/ her current level. Only analysing the answer correctly is not enough for effective teaching. Student should monitor based on the feedback that they receive while learning and how they learn from their mistakes are considered in this context. Student achievements and rewarded attempts are stored and analysed so based on that their knowledge level is captured. Selecting the exercise suggestion is done according to the best teaching approaches used in physical classroom and while considering the relevant pedagogical theories. The third research question is also addressed within this project.

6.1   PROBLEMS ENCOUNTERED

The main problem encountered within the project is the time duration. 300 hours was not enough to implement full complete Intelligent Tutoring System. Such ITS have huge knowledge bases to cover all the programming concepts of a language. Due to the time constrain it has been decided only to implement basic programming concepts for beginners. It also covered the necessary subject components for all the courses offered at the institute. But to address the research problem all concepts are implemented according to the research questions.

Also at the beginning it was planned to address the alternative solutions for an exercise activity up to a certain level but it was not able to cover based on the difficulties of comparing the language tokens generated by ANTLR with the stored possible solutions available in the database. And also logical error tracking is not covered in this solution as it require keeping and maintaining all possible intermediate states of the solutions provided by students for a given specific exercise. Most researchers mentioned that comparing the final solutions achieved by the student have to be compared with the actual final result(s) of the specific exercise but for programming related subject it will not be enough to capture the real logical problems exists in the provided answer by the students. It was noted that when naming identifies and literals students are not following the instruction as given in the activity outline but are able to considered as correct answers. So it excludes the logical error handling part.

To get the real advantage of peer engagement students are advised to use the implemented tool only during course hours. It blocks the opportunity of using the system in they own phase and convenient time. Due to the resource constraints only selected sample population is used for the evaluation process. It limits the opportunity of getting the feedback from entire target crowd of the learners who are going to use this tool for their studies in the future.

Even though the evaluation is focused on both experimental and interview & opinion based most of the data gathered are in the nature of qualitative, only limited quantitative data are available after conducting the evaluation of research.

Mainly all those deviations had to be done because of the limited time constrain and the technical difficulties faced during the implementation. But in general can satisfy with what has achieved and based on the successful feedback returned by the users.

6.2 FUTURE ENHANCEMENTS TO THE SYSTEM

Following are the areas that have been identified for future improvement of the system based on evaluation feedback & suggestions and authors own ideas.

- Include more advance Python programming concepts in knowledge base. Currently the system handles only the basic theories of Python programming language. If all the concepts are included, then the system will be suitable to cater all students with different Python knowledge levels.

- Divide the knowledge components in to smaller parts. Then the students' knowledge level on those small units can be maintained and efficiency of exercise suggestions can be made more advanced by that.

- Improve current user interfaces using universal design theories and with enriched technologies. Need to make them more interactive, user-friendly and accessible. That makes the system equal to the metal model of the system users. Also the interfaces are designed by having the mind set of tool will be best usable in desktop and laptop computers. So needed adjustments will be made it suitable for use it by all range of devices including tablet and smart phone with any screen sizes and resolutions. Still it is best visible using Mozilla Firefox / Google Chrome web browsers and in the future it will be supported by most modern web browsers to make the tool cross browser compatible.

- Implement a process to identify unnecessary program statements in the answers. Current system doesn't have the ability of identify statements which doesn't contribute to the final results. This can be added to logical error check of the solution and it can increase the accuracy of student answers and the feedback must be adjusted based on the logical mistakes that learners do.

- Include more pedagogical theories and cognitive analysis principals to the system. This system doesn't use all the teaching techniques for its lessons. Students' knowledge can be improved more by using latest pedagogical techniques and theorise to the ITS.

- Make the system compatible on identifying and providing the alternative solutions in its best possible way will be a competitive feature for such an ITS. It will be really helpful to students to get a deeper understanding about what other ways that they can use to look at on a similar problem.

- It was planned to continue the research to find the most appropriate way to tackle the logical issues done by a students during exercises. It helps to use this solution as a universal solution during any level of python programming courses for evaluating students and their knowledge completely. But the current standing can only cover and provide the feedback and support based on the mistakes that they do to break the language rules and semantics.

- Will be focused on continuing the tool to support other industry popular programming languages and platforms such as C#, Java, PHP too. As an example if the tool can be enhanced to support multiple programing language support using a single tool, it can collectively be beneficial for the academic industry.

- Finally once the solution is ready with those shortcomings, the system will be opened to all the students available in different branches in the EOSFT company networks. It will create equal opportunity for all the students learning IT as major subject. It was decided to continue this research discipline during my higher studies as well.

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APPENDIX A: QUESTIONNAIRE FOR LEARNER ANALYSIS

1.   What is your age?   ………………………………..

2.   What is your gender?   ☐ Male   ☐ Female

3.   What is your primary language?   ☐ Sinhala ☐ English ☐ Tamil

4.   What is your employment?   ……………………………….

5.   What is your highest educational level?

     a.   O/L

     b.   A/L

     c.   Diploma

     d.   Higher National Diploma (HND)

     e.   Degree

6.   Number of years that you have learnt IT?   ……………………………….

7.   What is the level of your computer literacy?

     a.   Beginner

     b.   Intermediate

     c.   Advanced

8.   What is your level in programming?

     a.   Beginner

     b.   Intermediate

     c.   Advanced

9.   What are the programming languages that you are familiar with?

……………………………………………………………………………………….………

     ………………………………………………………………………………………………

     ……………………………………………………………………….…………………

10. Do you have any experience with Python Language?   …………………………...

11.   What is your mostly preferred learning method?

………………………………………………………………………………………………………

………………………………………………………………………………………………………

12. Do you have an internet connection at home?   …………………………..

13. If yes, what is the connection type?   …………………………..

14. What is your online experience level?

    a. Frequent

    b. Rare

    c. Never

15. Rate your own cognitive and metacognitive skill levels.

Skill	Excellent	Good	Poor
Perception Recognition and interpretation of sensory stimuli (smell, touch, hearing, etc.)			
Attention Ability to sustain concentration on a particular object, action, or thought, and ability to manage competing demands in our environment.			
Memory Short-term / working memory (limited storage), and Long-term memory (unlimited storage).			
Visual & Spatial Processing Ability to process incoming visual stimuli, to understand spatial relationship between objects, and to visualize images and scenarios.			
Planning Selection of suitable approaches and the correct allocation of resources that increase or decrease task performance.			
Monitoring Awareness of task performance			
Problem Solving Defining the problem in the right way to then			

generate solutions and pick the right one.			
Decision Making The ability to make decisions based on problem-solving, on incomplete information and on emotions (ours and others').			
Sequencing The ability to break down complex actions into manageable units and prioritize them in the right order.			

16. Do you have any learning disabilities?

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

17. Do you have any cognitive disabilities?

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

APPENDIX B: KNOWLEDGE COMPONENTS OF SUBJECT CONTENT

- Python Basics
  - Simple Programs
  - Lines & Indentations
  - Multiline Statements
  - Comments

- Python Variables
  - Identifiers
  - Numbers
  - Casting
  - Strings

- Python Operators
  - Arithmetic Operators
  - Assignment Operators
  - Comparison Operators
  - Logical Operators

- If…Else
  - If Statements
  - Elif
  - Else
  - Short Hand If
  - Short Hand If…Else
  - And & Or

- While Loops
  - While Loop
  - Break Statement
  - Continue Statement

- For Loops
  - For Loop
  - Looping through a String
  - Break Statement
  - Continue Statement

APPENDIX C: PRE –TEST QUESTIONS

1. What is the valid keyword in Python from following words?

    a. prints
    b. class
    c. For
    d. While

2. Select all invalid keyword in Python

    a. Else
    b. if
    c. elif
    d. class

3. Select the valid Python identifier from the list below :

    a. varId2
    b. 2varId2
    c. _varId2
    d. var Id2

4. In Python, the '+' operator is working as 'addition' operator for two numeric operands. What is the operation of '+' operator when two String operands are provided?

    a. Cannot be determined.
    b. Merging two string operands together with the + mark in the middle.
    c. String concatenation.
    d. None of the above.

5. In Python, "elif" is used in :

    a. Sequence control structure
    b. Repetition control structure
    c. Selection control structure
    d. None of the above

6. Select the correct output of the following Python code.

    i="Hello"
    i+="_Python"
    print(i)

a. Hello Python
b. HelloPython
c. Hello_Python
d. Program does not run because of an error in the code.

7. Select the correct output of the following Python code :

> **name="Simon"; age=25**
> **print("My name is", name ,"./nI'm" , age , "years old.")**

a. My name is Simon. /nI'm 25 years old.
b. My name is Simon .
   I'm 25 years old.
c. My name is name. /nI'm age years old.
d. My name isSimon.
   I'm25years old.

8. Select the correct output of the following Python code :

> **a = 202**
> **b = 203**
> **c += b**
> **print(c)**

a. 203
b. 202
c. 204
d. None of the above.

9. Select the correct output of the following Python code :

> **x = 30**
> **y = 29**
> **z = 30**
> **print(x <= y)** *# Line 01*
> **print(y >= z)** *# Line 02*
> **print(x != z)** *# Line 03*

	Line 01	*Line 02*	*Line 03*
a.	True	True	False
b.	False	False	True
c.	True	False	True
d.	False	False	False

10. Select the correct output of the following Python code :

```
a = 2
b = 3
c = 1
res = (a * b) % c
print(res)
```

a.   1
b.   10
c.   0
d.   6

11. Select the correct final values of variables used of the following Python code :

```
x = 12; y = 5
q = x // y
r = x % 2
e = y ** 3
d = x / y
```

	q	r	e	d
a.	2	0	125	2.4
b.	6	2	125	2.4
c.	2	125	15	2
d.	6	0	15	2.4

12. Select the correct output of the following Python code :

```
a = (2 ** 2) // 2
b = 2
c = 4 % 3
print(a != b)  # Line 01
print(c != b)  # Line 02
```

	Line 01	Line 02
a.	True	True
b.	False	True
c.	False	False
d.	True	False

13. Select the correct final values for x and y:

$$x = 26$$
$$y = 14$$
$$x\ //= 15$$
$$y\ \%= 3$$

	x	y
a.	2	1
b.	3	2
c.	1	2
d.	2	2

14. Select the correct output of the following Python code :

```
a = 1
for b in range(3)
        a += b
        b += 1
print(a)
```

a. 7
b. 3
c. 4
d. Program does not work because of an error.

15. How many times does the following loop iterate?
```
counter = 2
while counter >= 10:
counter += 2
```

a.   5 times
b. 0 times
c. Infinite times
d. None of the above.

16. What is the valid condition that can be applied to get the same exact output as follows:
Code:
```
count = 1
while ……… :
        count += 1
        print(count)
```

Output:

> **2**
> **3**
> **4**
> **5**
> **6**

    a. count <=5

    b. count <5

    c. count <6

    d. count <=4

17. What is the valid condition that can be applied to get the same exact output as follows:

Code:

```
a = 3
while ……… :
        print(a)
        a += 2
```

Output:

> **3**
> **5**
> **7**
> **9**
> **11**

    a. a<12

    b. a<11

    c. a<=11

    d. a<=10

18. What will be the final value stored in variable 'c' after running the code below?

```
c = 10
while c >= 0:
        print(c)
        c += 1
```

    a. 10

    b. -1

    c. Cannot be determined

    d. None of the above

19. Select the correct symbols to be placed inside the numbered placeholders in following code to make it work:

```
for i in range(10) 01
        print("Value of i is:" 02 i)
```

	01	02
a.	:	+
b.	:	,
c.	Nothing	+
d.	Nothing	,

20. Select the correct output of the following Python code :

```
a = 0
for i in range(5):
        a += (2 * i)
        print(a)
```

a	b	c	d
0	0	0	2
1	2	1	6
3	6	2	12
6	12	3	20
10	20	4	30

APPENDIX D: FEEDBACK FORM

Please rate the characteristics of the system

1. User Interfaces

    o Very Good
    o Good
    o Average
    o Poor
    o Very Poor

2. Usability

    o Very Good
    o Good
    o Average
    o Poor
    o Very Poor

3. Programming Exercises

    o Very Good
    o Good
    o Average
    o Poor
    o Very Poor

4. Exercise Selection Methodology

    o Very Good
    o Good
    o Average
    o Poor
    o Very Poor

5. Feedback Messages

    o Very Good
    o Good
    o Average
    o Poor
    o Very Poor

6. Success in Improving Python Knowledge

   o Very Good
   o Good
   o Average
   o Poor
   o Very Poor

7. Overall Impression about the System

   o Very Good
   o Good
   o Average
   o Poor
   o Very Poor

8. Do you think the knowledge of students in Python Programming will improve by using the system?

   ----

9. Will you recommend the system for the other students?

   ----

10. Did the feedback provided by the system was helpful to understand errors?

   ----

11. What do you feel about the Exercise Suggestions of the system? Are they appropriate?

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----

12. Did the system analyze the answers correctly?

----

13. Does the system handle alternative solutions to a given problem properly?

----

14. Does the system identify your knowledge level accurately?

----

15. What do you think about user interfaces of the system?

----

16. What are the new features would you like to add to the system?

----

17. Any other comments about the system.

APPENDIX E: USER MANUAL

Following section provide details to the system users about the important tips useful when experience the developed system. Users of the system are encouraged to read this section before start using the system, because it covers all the aspects related to practical operations of the implemented platform. Contents are organized based on the functionalities provided by the system. It makes to the user experience equal so any one can quickly adapt with the python ITS. Students only require a basic device with a standard web browser to start practicing this system. Following are the basic prerequisites of the system.

- Standard Computer
- Speakers / Headset
- Web Browser

Desktop or laptop computer, speakers, Mozilla Firefox are recommended to gain the best user experience. Smaller screen sizes and other devices/platforms can resulting difficulties when accessing the interface elements.

How to Access ITS?

- Open web browser (any)
- Type https://www.esoftbattaramulla.lk/pits
- Press **Enter**

Note that every user must have a valid login details to get access the system. So any user new to the system must create their own system account. YOU MUST NOT share your login details with anybody else. If you do so it is identified as offensive and you will be penalized for such activities.

How to Create a User Account?

- Go to **Login page** of the Python Intelligent Tutoring System (PITS) website
- Click on **Register** tab
- Enter the required details
- Click on **Register** button
  Or
- Click on **Register** link from the main navigation panel in the header area of the website

Now you can start accessing the system using the newly created account. You can use the same location (page) Login tab to login to the system, and you are asked to enter the username and password combination to enter to the system. You can check the Remember Me option, if you do so your username will be kept remember for a period of one week (7 days). You are strongly recommended to do this if you are the only user accessing the system by the specific accessing device. If not always type it manually and log into the system to avoid security concerns.
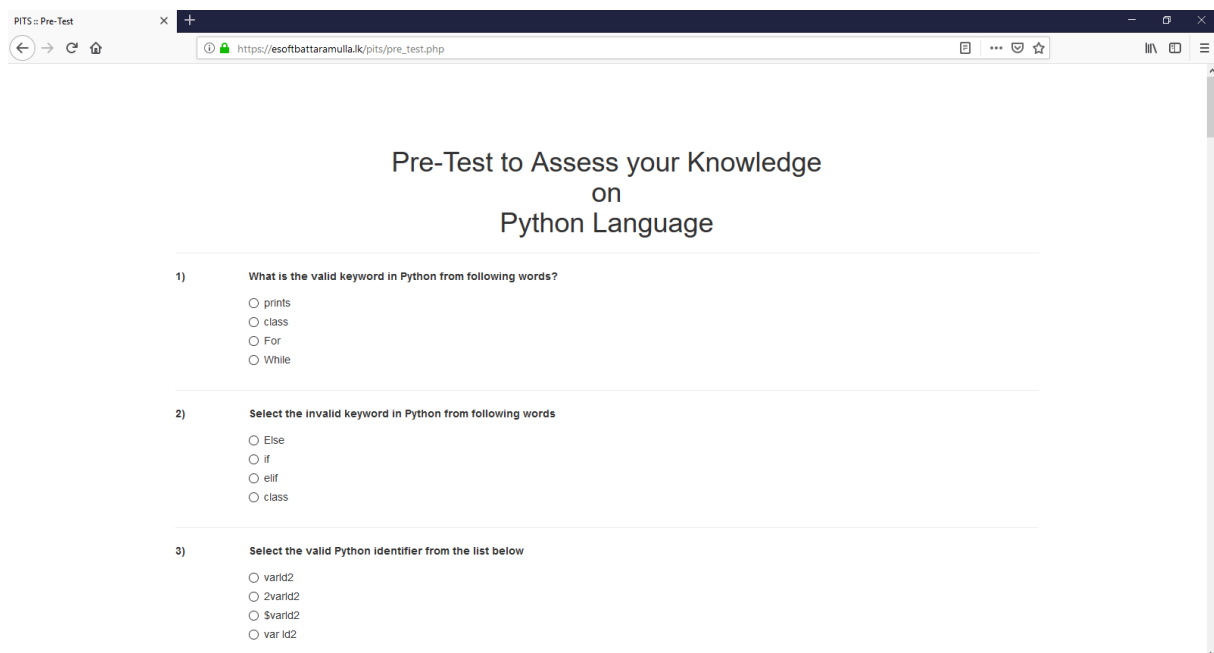
Then as a beginning every student must check your current knowledge level by participating for the Pre-Test which is use for the purpose of initial skill level assessment. When you log in to the system for the very first time, if you do not already completed your Pre-Test then you will be redirected automatically for the Pre-Test page. You are required to complete the given **40** MCQ questions in one go. Your score and time taken to complete the Pre-Test will be recorded in the system. Your weaker areas and suggested exercises are selected based on you answers provided for each question. So all learners are supposed to complete it by your own without cheating to get actual standing on the python course that you are taking. First initial feedback on your work is given in the **Pre-Test Results** page. It can be used to check your answers and the system expected correct answer for the questions that you mark incorrect answers. It uses three colour schemes green for the questions that you mark the correct answer, red for the questions you mark incorrect answer and the correct answer for that specific question is highlighted with the yellow colour.
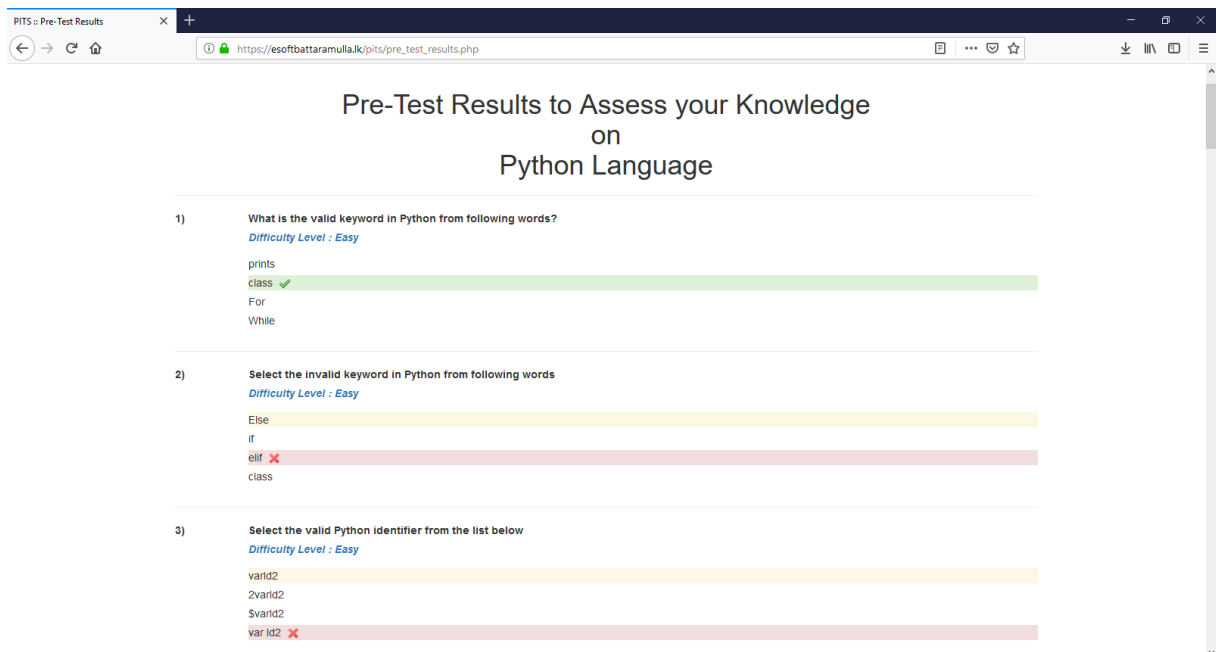
System will produce a graph that indicate your weaker areas and the specific areas that you must put your attention based on sub topic specific sub charts.
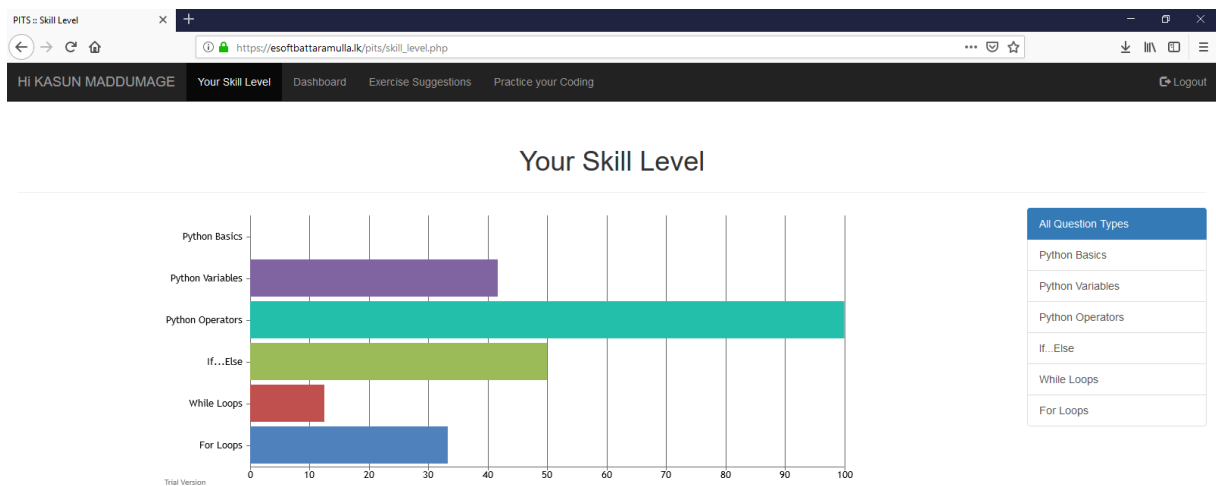
Once you are done with Pre-Test then your real journey begins. So use the below image to get familiar with the main navigation module of the PITS.
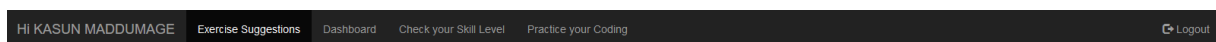
To practice your own code with a code block module you can visit to the **Practice your Coding** page link available in the navigation panel. Then you can run your own code presences to see the error/output generated by those code samples. It is similar to your Python Integrated Development and Learning Environment (IDLE) and you can type your own code and practice your knowledge/skills before you are really being tested.
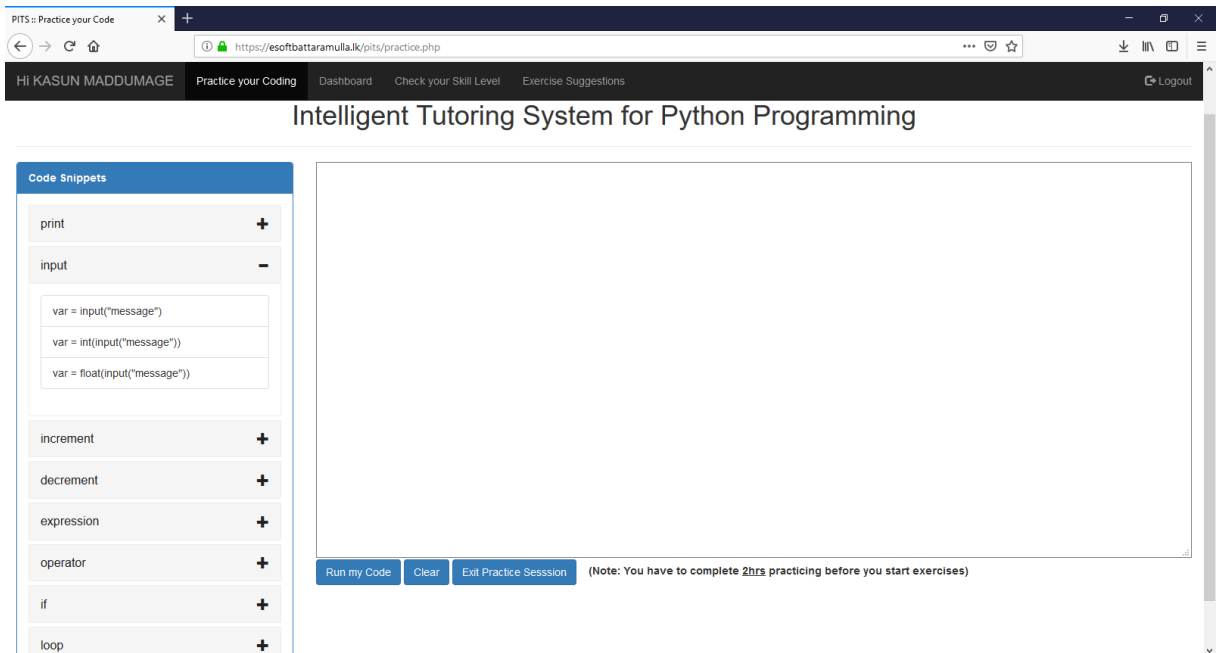
Here you will be given the code snippets so you can practice the skills needed using those code blocks. You are only required to replace the pre-defined wording as per your expectation. There are less chances for the beginners to make mistakes due to the lack of knowledge on the domain. So they can practice and practice and can build the necessary skill before they sit for real exercises.

Next major sections of the developed ITS are;

- Exercise Suggestion
- Exercise Selection
- Exercise Page
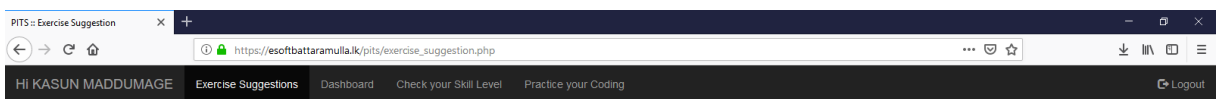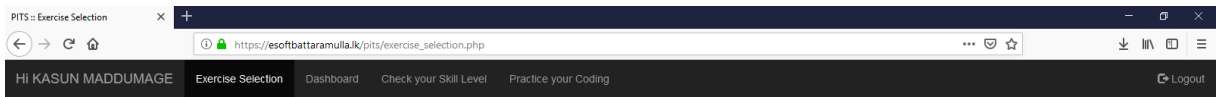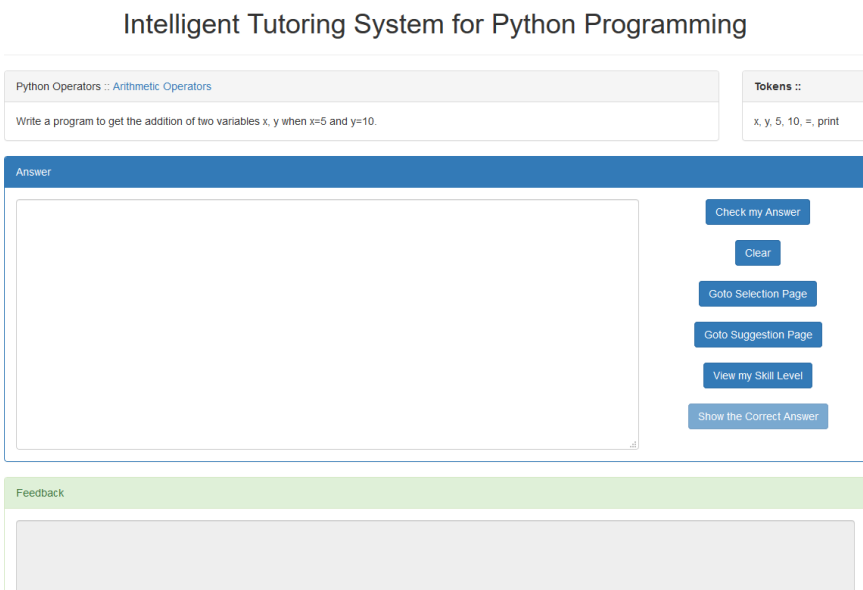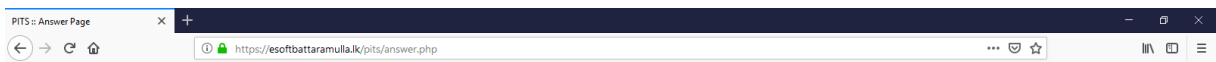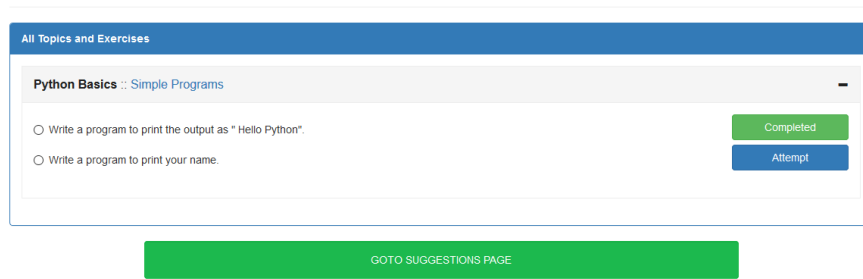
You can view the suggested exercises by the system according to your knowledge level using Exercise Suggestion page. Then based on the exercise topic/area suggested you can pick an exercise by visiting to the Exercise Selection page. Then you can view each exercise by visiting to the Exercise page by clicking on a specific exercise by Exercise Selection page. System will provide **3** exercise **types** and **3** exercise **sub types** suggestions, once you progress through the course the list will update with the more difficult and advanced topics. It allows to guide you while taking exercises, because the content are organized by the topic order in your course textbooks for your own comfort and easy flow. All your errors, feedback, suggestions and system help are organized around Exercise page where you can provide your answer for a given question in a specific exercise. Above are some screenshots captured by the ITS for your own reference.

There are 3 main button types available in Exercise Suggestion and Exercise Selection pages. If you already completed a specific activity or a topic, button will be changed into the green colour with the "**Completed**" caption. If you already attempted for a specific exercise and unluckily unable to complete the exercise button colour will be changed as yellow colour with the caption "**Re-Attempt**". But note that for each activity you will get maximum of **3** attempts to obtain the marks allocated for that specific exercise. If you exceed the 3 attempt yet you can complete the exercise but **no marks** will be provided for that specific activity. You exercise marks will differ according to the difficulty of that exercise. There are 3 main difficulty levels namely **Easy**, **Medium** and **Hard**. It is similar to the Pre-Test Questions, they also follow the same standard but equal marks are provided for Pre-Test questions.

Final tip is note that you timings on each activity are closely monitored by the system and don't waste any time unnecessarily. Read each feedback given by the system to progress effectively in your python course.

Your personal profile management, communications are grouped under **Profile** page. Your peer engagements are listed under **Message** section. Important links required for your level check and progression are also located under Profile page.

Rate your thoughts, feedbacks and suggestions about the ITS to make it improved and to provide the best service as you expected by the implemented system. Herewith we are not adding samples related to your Exercises and Feedback, because the feedback and suggestions given during activities are situation based. It will give the same feeling like you are working with your friends and subject teacher.

You are REWARDED by your achievements. You earnings will be listed under the "**Top Performers**" section in the **homepage**. But keep in mind you have to do your level best to keep a slot reserved in that section. And also you can improve your knowledge by following

the instructions given in the "**Tip of the Day**" section. Additional useful links and guidelines are also listed in the homepage.

THANK YOU & GOOD LUCK !!!