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Enhance Programming Practices Through an Online System

**A dissertation submitted for the Degree of Master of
Information Technology**

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University of Colombo School of Computing

2018



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.

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

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

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LIST OF ABBREVIATION

IDE	-	Integrated Development Environment
HTML	-	Hyper Text Markup Language
UML	-	Unified Modelling Language
PHP	-	Hypertext Pre-processor
ERD	-	Entity Relationship Diagram
CSS	-	Cascaded Style Sheet
JSP	-	Java Servlet Pages
SQL	-	Structured Query Language
JSON	-	JavaScript Object Notation
FAQ	-	Frequently Asked Questions
JRE	-	Java Runtime Environment
C4droid	-	C for android

ABSTRACT

Programming is an important area of Information & Communication Technology under G.C.E. Advanced Level Examination which needs to be covered theoretical, logical and practical aspects of the curriculum. Python is the programming language which is used for practical exercises for advanced level students and python is becoming a popular language for teaching introductory programs. There is a need of an environment to practice programming concepts for students to improve their programming skills.

Practicing programming is hard when students have to follow number of pre-activities for installation before starting their coding part. The most important thing is to give basic concepts of programming for students. Therefore, it is important if we can give an environment to practice with a suitable programming language without having an effort for installation part. For that we have to allow students to skip from backend processes for setting up the environment and other installation part. We can allow them to work with an interactive environment to practice programming.

Project title is “**Enhance Programming Practices Through an Online System**”. The key objective of this project is to provide a web service for learning-teaching process for Python. This is a web-based system which can be used by students to write python programs directly in the web browser without installing any plugins. They can view the results/output of the system, and they can see errors available in the python code. Students can view analysis report of the given python code. Students can practice programming with a user-friendly environment which helps them to study without hard working on preparing the environment.

Through this system the student can enter a python program and the student can see result of the python code entered. Result will consist with errors of the code and user interface will display those errors if available. If the python code does not contain any error, it will display the output of the code. After running the python code properly, students will get the user interface which will provide the provisions to analyze the program for checking the quality. Therefore, students will practice their python codes through system and they will work with good practices in programming as they can analyze their codes.

Through this code validation system, it is expected to be achieved that “*Develops algorithms to solve problems and uses python programming language to encode algorithms*” which is the competency of the chapter “Programming Concepts” in G.C.E.(Advanced level) syllabus and to help students to practice more according to the requirement of each individuals.

CHAPTER 1 - INTRODUCTION

1.1. Introduction

Information & communication technology (ICT) is recognized as a tool to improve efficiency, productivity & effectiveness of any organization or any other individual's activities. It is important to have the knowledge of ICT and practices to an adequate level of an individual. One of the requirement of introducing programming for ICT in general education is to improve required skills for the development of solution for day-to-day problems.

From 2009, Sri Lankan students have been introduced ICT for G. C. E (Advanced Level) with objectives such as giving a foundation for ICT education leading to students' higher education, Improving the skills for the development of ICT based solutions for real world problems, enhancing the students' knowledge on ICT which can be applied in other fields etc. The ICT syllabus at G.C.E. (A/L) consists the core concepts of ICT covering both theoretical and practical aspects. And this subject will provide an added advantage to students by improving their soft skills, thereby enabling them to be best fit into working environments.

According to the curriculum, few different aspects of ICT have been included for G.C.E.(A/L) to achieve above objectives. Those aspects can be mainly divided into 3 parts as theoretical, logical and practical. Some of the contents in the subject (ICT) covers theoretical and practical aspects only and there are some contents which covers all the aspects. Students who study programming has to fulfil all the theoretical, logical and practical aspects.

The observation made from students who study programming is that the practical aspects are interesting for them but they are not attracting for the theoretical and logical aspects like practical. Therefore, those students are not achieved expected objectives through the subject. They prepare only for the examination with the objective of having a "Pass" from the exam. Because of this, most of the students are unable to get their expected results and therefore the next batches who are willing to select ICT for advanced level examination, are also stumbling at their selection. And when those students are doing their higher studies with ICT (specially programming), they face many problems with the subject.

1.2. Problem Background

Programming is one of the theoretical and logical aspects in Advanced Level ICT subject. It is discussed in 74 periods (15% of total periods) and the students can earn around 18% marks for the final examination from this aspect.

“Develops algorithms to solve problems and uses python programming language to encode algorithms” is the competency that the student should achieve at the end of the chapter “Programming Concepts” in G.C.E. (Advanced level) syllabus. Through this, the student shall be able to apply their skills in solving problems into real-life scenarios. But the students do not reach this targeted endpoint. The identified reason for that observation is that the students try to cover the theoretical aspects by targeting their final examination and they are not attracting for the theoretical and logical aspects like practical. They are not trying to improve their problem-solving skills and not applying those solutions for problems.

Many of the students get rid of learning/ practicing programming concepts. One of the major reasons is that the traditional teaching-learning pattern such as chalk and board method is not a successful and effective method for giving programming concepts for students. Teaching programming is something which teaches to develop solutions for real time problems by using the improved internal logical thinking ability of a student. To improve logical thinking ability of a student, he has to get the concept and practice the concept with different types of exercises.

To practice with different types of exercises, students need to use an environment with a programming language. When a student is going to practice with a programming language, first he has to fulfil the requirement for that environment. Most of the times he may have to install another software or he has to prepare the required environment for it. If that preparation is hard, then that student may get rid of that learning part and he will try to cover theoretical part only.

There are different kinds of software tools on the internet for programming. But most of them are not motivated to practice with problems due to the complex environment and less user friendliness according to their knowledge levels.

Lack of knowledge/use of good practices of programming is another problem in this area. Students may practice programming with different exercises but they may not concern about the quality of codes. Therefore, most of the students are not considering about good practices of coding. Students need a real-time support to get comments on their codes.

1.3. The problem

The main problem of this domain is lack of having an IDE for students to practice programming concepts without having complex pre-requirements. Students need an environment to practice programming concepts with given problems using a selected programming language. It is required to have an interface for practicing python codes and to find out errors of the code. When students work with python programs, it is important to check the quality of the python code. For that students need an interface to analyze the python code.

It is important to provide an online environment for them to practice programming concepts without having complex installation part or any other extra pre-requirements before coding. There are some online systems available which can be used to practice programming and students can get the output or error report at the same time. Some of them are free and open source and some are proprietary software. But most of the systems are complex and students have to do some pre-activities before using them. Some systems allow students to enter the code and get the output/error result. But those online systems do not allow students to analyze the code to see the quality of the code. Some systems allow user to analyze the code after giving the complete program to the system but students do not get opportunity to enter the code and to run it to get the output.

It is required to have a system or an interface where the user can access easily and which provides a user-friendly environment for the user to practice programming concepts. They need to check the quality of the program by themselves and to find out issues of the code given and it will give them opportunity to correct and continue with development continuously.

1.4. Motivation

Through an online system or an environment, students are able to practice programming concepts from the beginning. It provides free environment for students to work without concerning about software installation or any other pre-requirements. An enhanced environment can keep students with the system and they are able to practice with different problems. Then students will practice the code by modifying it until they get the correct output.

If a system can provide them an environment to practice programming, without having number of steps for pre-requirements such as installation of different software, they can spend more time with the system and they are able to try with more problem. While students are practicing with python codes, they may modify the code and try to find the best solution for the problem. And they can work with different types of solutions and they will run and test them as they can do it online. Automatically programming concepts will be familiar with the student without having hard effort.

If the system can analyze the python code and if this system can give errors of the program, it will help students to learn mistakes done by the student and they will correct it by identifying bugs in the code. Then automatically students may addict with this learning environment and try to do more exercises.

Students may work with analysis part of this system and through this they will try to use good practices for programming. Gradually they can write programs with the best solution and with the support of good practices.

Students can learn python not only for G.C.E. (Advanced Level Examination), they can practice continuously according to their requirement. The online system will motivate any user to practice themselves without having any guidance of others.

With all of above factors student may improve the skill of finding a solution and think about algorithms for a given problem and converting that solution into a program. And they may try to improve their program with quality codes by reducing errors and some negative points. With this identified skill of programming and developing algorithms, part students will improve their logical thinking power and they will address properly for problems they face in the real life also.

1.5. Aims and objectives

1.5.1. Aim

Support students for learning of programming and python language for A/L ICT

1.5.2. Objectives

- O 1 To provide an IDE for students to practice programming.
- O 2 To allow students to see errors of the python code entered.
- O 3 To allow students to analyze their projects to check the quality of the code.

Students have an IDE to practice programming through this system. Specially this system targets G.C.E. Advanced Level Examination Students who follows Information and Communication Technology as a main subject. As python programming language is the practicing language for G.C.E. (A/L) ICT, this system allows students to practice python programming language.

Students can give a python code to this system and system will be interconnected with interpreter to give results of the python code entered by the student. SonarQube environment is integrated with this system to measure the quality of the python code by analyzing it. User may not see the internal process but the user work with the interface to enter the code, see the output or errors.

They will see the output or errors of the python code which is given to the online system. According to the error report given by the system, the student can quickly navigate to the line of the program which has occurred the error. The student may correct & re-check the program and the student may continue modification process until he gets the correct output. User can find the best solution for the given problem without wasting time and he can reach the final solution.

User can get the analysis report of the python code which describes the quality of the code. Then user can improve the code furthermore and he can check it.

Through this online system, every student developer will improve the ability to think about the quality of the code in this way.

1.6. Scope of the project

S 1 To provide an IDE for students to practice programming.

Through this online system, an IDE is to be developed which allows user to enter the python code and to submit the code. Interface shows the output of the python code and it generates errors of the code if available. Analysis results of the code will be displayed. This system allows students to download the python program entered by them.

HTML, CSS and PHP are used to develop the online system.

S 2 To allow students to see errors of the python code entered.

System can check the python code entered by the user and if any error is there with the system, it will display the error for the user by mentioning the line of it. Then the user can modify the code and again he can check the python code.

S 3 To allow students to analyze their projects to check the quality of the code.

Executed python code can be analyzed by the system and the quality of the code is measured through this system. System will display the quality of the code with some factors such as lines of codes, duplicated blocks, duplicated line density, etc. This system allows students to analyze a project/ code of the solution to learn and improve the quality of the system.

1.7. Methodology

A system development methodology is a framework which is used to structure, plan, and control the process of developing the proposed online system for python programming practices. There are wide variety of such frameworks which are used in numerous projects in the real world. Each framework has its strengths and weaknesses.

Waterfall, Spiral, incremental and prototyping are some of these methodologies that a developer can apply for a project.

Based on the identified requirements of a project, we consider which methodology is suitable for the particular project. Each of the available methodologies can be considered as the best suited to specific kinds of projects, based on various technical, organizational, project and team considerations.

This online system for python programming practices can be identified with modules to be developed and therefore the system can be breaking down into identified smaller segments. And it provides more ease of change during the development process. And we can apply linear development with iterative concept for the development of this online system. By considering above mentioned features of the online system for python programming, linear and iterative methodologies are suitable for the development of the project. Therefore, incremental methodology is appropriate for this system.

Incremental methodology is a combination of linear and iterative system development methodologies and it provides developer to work with modules. And it is a series of mini waterfalls where all phases of the waterfall development mode are completed for those modules before proceeding to the next increment.

Prototyping methodology can be used as a tool for capturing requirements for the online system to make ease of design and development in the future stages. As we can see more user involvement of the user with prototyping, we can develop a well user satisfied system. And also, as user can see a working version of the project from the early stages of development of the system he can have a good idea of what he needs and what is going to be developed. All these things lead to a well-developed system which satisfied user requirements highly.

1.8. Expected Outcome

An online environment which allows students to practice programming concepts is the main outcome of this project. Student can work with the system with his own profile. The student should be able to work with a friendly environment without having hard steps for installation and they should be able to practice python programs. They can check errors of the given python code if errors are available and if the code is correct, output/result of the code can be checked.

The python code entered by the student can be analyzed to check the quality of the code. Then they see the code quality with number of lines of the code, code smell, duplicated blocks of the code and etc. Student can download the python code entered as a python file and all the projects that the user practice as separate projects are stored with the particular user profile.

With all these facilities, this system can allow students to practice programming concepts with examples and this allows students to practice with different methods. And this online system will allow users to learn by practicing python codes at their own speed. User can practice the same code with different methods from any device at any time. Through this online environment, it is expected to motivate students to learn programming concepts with good practices in programming.

CHAPTER 2 - BACKGROUND

2.1. Background information relevant to the implementation

This system is to solve the above identified problems (*mentioned in Chapter 1.3*) and to fulfil requirements of users to practice programming concepts through an online system. This system is a web-based tool which helps users to practice python programs as this system is mainly designed for students G.C.E. Advanced Level students who follow ICT as a main subject.

Since this is a web-based system, internet is the only requirement that the user must have and user can access this from anywhere at any time. It is not required to have any other special software or any installation part as prior activities to use this tool. So, without having any pre-requirements user can start his coding part with the given space. And also, one user can manage all the projects which are practiced by himself with his own profile. Once he works with a project, his project is stored with his own folder which is located in the server space and later he can retrieve them and modify again.

The interface provides opportunity for the user with a user-friendly environment and user may get the quality of the code through the system. Quality of the program entered by the user is measured and evaluated by the third-party tool named SonarQube Which is a platform for programmers to check the quality and issues of the program.

As mentioned above issues of the program and problematic statements also shown to the user through the interface. So that the user sees the quality and issues of the code given by them with few steps. With the feedback given by the system for the code entered by the user, he/she can continuously modify his python code or the program and re check it. Until he gets the working version he may try out the code. And once it is completed, he can see the real output. If the working project/ the code is executed he can analyze the code/the program and then he continues the modification to improve the quality of the code.

SonarQube is the software platform which is integrated with this online system to allow users to analyze python codes. SonarQube is also free and open source platform. The python code entered by the student can be modified as it provides reports about the program and it will be easy for the user to improve his/her programming knowledge with good practices.

Finally, this interface is a place where users can practice programming concepts basically with python as a start. Internet is the only basic requirement for this system and user can work from any place at any time.

2.2. A critical review of similar systems available

Pythontutor - <http://www.pythontutor.com/>

Python tutor is a free platform for users to practice programming concepts and this allows user to write the code and to visualize its runtime state. This supports coding in five popular languages including Python, Java, JavaScript, Typescript and Ruby. This is a platform which helps users to overcome basic barriers to learning programming and to understand internal operations of the computer when each line of the source code runs in the machine.

Online Python Tutor is a web application with a backend written in Python and a frontend written using standard web technologies such as HTML, CSS, and JavaScript. The back end of the Online Python Tutor takes the source code of a Python program as input and produces an execution trace as output. This executes the input program under supervision of the standard Python debugger module and it stops execution after every executed line and records the program's run-time state. The trace is an ordered list of execution points, where each point contains the state right before a line of code is about to execute. This includes The line number of the line that is about to execute, the instruction type, global variable names to their current values & program's output up to this execution point and etc.

The frontend is a website located at pythontutor.com, which renders in all modern web browsers without requiring the user to install any extensions or plugins. The user first sees a text box and can type (or paste) a Python program into there. When the user clicks the "Visualize execution" button, the frontend sends that program to the backend; the backend then sends back a JSON execution trace, which the frontend renders in a GUI.

User enters the code/ program in the given space area and he gives the command to visualize the execution. Then this code or code segment is sent to the Online Python Tutor server for execution. Then server trace out the complete execution and send it

back to the browser of the user and then step by step he can see the execution. At each execution point user may see internal execution, memory allocation with given variables names. And also, he can see errors of the python code entered by him.

There are some limitations identified with online python tutor when we study about it. It steps through execution one line at a time like a debugger. And it does not show the details of expression and subexpression evaluation. In contrast, but some users have requested stepping functionality.

Another limitation of online python tutor is scalability. Online Python Tutor can visualize only several hundred execution steps of programs with relatively small data structures. But it is not meant to be used for debugging production sized software systems. However, we may investigate how to cache and visually summarize large data structures to scale up to larger pedagogical code examples.

Currently we can execute and visualize linked lists well, but not for more sophisticated data types. It is important to have executions for trees, graphs, numerical matrices, and other data structures.

Although the user can work and visualize the code, it does not contain facility to check the code quality of the program with python online tutor.

Python IDE for Professional Developers - <https://www.jetbrains.com/pycharm/>

JetBrains PyCharm is an Integrated Development Environment for programming using Python. PyCharm is a platform which provides smart code completion, code inspections, on-the-fly error highlighting and quick-fixes, along with automated code refactoring for developers and it provides rich navigation capabilities. Two editions are there with PyCharm platform such as Community and Professional. The Community Edition is free and open source but it has less features than professional edition. But the Professional Edition is commercial and it provides an outstanding set of tools and features.

JetBrains PyCharm is having following key features:

- Intelligent Editor for Python with code completion, on-the-fly syntax and error highlighting and code inspections
- Code Refactoring including rename, introduce variable, introduce constant, pull up, push down and others

-
- Web development with Django: with specific templates editing support, server launch from IDE and best in class support for HTML, CSS and JavaScript editing.
 - Project and Code Navigation specialized project views, file structure views and quick jumping between files, classes, methods and usages
 - Error-Free Coding on-the-fly code analysis, error highlighting and quick fixes-errors of the program will be highlighted and the user will be facilitated to fix them quickly.
 - VCS Integrations out-of-the-box support for Subversion, Perforce, Git, Mercurial and CVS with change lists and merge
 - This platform is a Cross-platform which works on Windows, Mac OS X and Linux operating system

Python is very sensitive to code formatting by its nature. The very basic requirement to keep your code in a consistent state is to preserve the same formatting style across all over your project. PyCharm has a special subsystem that controls code style and inspects different code style violations. It watches for code formatting rules like tabs and indents, spaces, wrapping and braces, blank lines etc.

When we consider hardware requirements for PyCharm environment following requirements can be mentioned.

- 1 GB RAM minimum or 2 GB RAM
- 1024x768 minimum screen resolution.

As system requirements following requirement can be mentioned.

- JRE 1.8 is bundled with distributions for all platforms.

It is not needed to install JAVA on your machine in order to run PyCharm. The installation process depends on the operating system of the user's computer.

As it provides fully functionalities with its commercial edition, some requirements are limited for users who use community edition. Therefore, users who use community edition are getting functionalities without having some additional features. And there are some pre-requirements to be completed by the user before running the JetBrains PyCharm integrated development environment.

2.3. Alternative technology options

- **Standalone system to practice programming concepts.**

Standalone system or platform is another technology option for this type of software output for the user. So that the user can use the system even without Internet facility. Standalone system can also be developed quite similar to web-based applications. This type of system provides the programmer to have full control over the interface within the capabilities of the operating system.

But there are some problems with standalone systems. Limitations on updating of the system can be seen with this system. And user has to bring the software to where they move and to the machine which he uses. User has to carry out what he is doing to places where they go.

- **Mobile app to practice programming concepts**

This online system can be given to the student as a mobile app to allow them to use the tool through wireless connections. Following systems are some of the mobile apps which are available for practicing concepts of python programming with exercises and questions for python learners. There are advantages and some disadvantages of each when we consider those systems for Advanced Level ICT students who learn Programming concepts.

SoloLearn

SoloLearn is FREE code learning content, from beginner to programming. It helps users with programming topics to learn coding concepts, brush up their programming knowledge, or stay aligned with the latest coding trends.

They will be greeted by the friendliest community of coders, where peer support is an essential part of learning and development. Fresh learning content is created by the community daily, facilitating efficient and effective coder skill improvement.

Users can join at anytime from anywhere and they can access to countless coding topics and assignments. They can write and run real code on Android's #1 mobile

code editor, they can get inspired through real-life code samples, and engage in interactive community conversations along the way.

There are following features with SoloLearn to learn python for users.

- SoloLearn is personalized where content is delivered based on your progress, preference, and hottest market trends.
- Users can access free and it is available 24days in days with peer support. Ongoing community support and real-time alerts make learning to code as easy and enjoyable as it can possibly get.
- SoloLearn is free to share knowledge. It has created lessons in user's area of expertise and this app improves user's profile with each achievement.
- This is a free mobile code editor which can use to write, run, and share real code right from user's mobile, without any additional installations and setups.

There are many advantages of this SoloLearn mobile app for python learners such as mobile app allows user to learn anywhere, comprehensive lessons that teach both basics and more advanced details, hands on ability to practice writing in the programming and coding languages of user's choice and multiple courses to choose from given list.

There are some disadvantages of this mobile app such as teaching the grammar and vocabulary of programming languages but lacks in depth teaching about how to apply said grammar and vocabulary.

Learnpython

Learnpython app enables user to carry basic Python programming notes in user's android. It contains about 40+ Python Programs, and many FAQ's. This app has a very simple user interface and the contents can be easily understood by the users.

This will definitely help user for preparing for interviews, tests and in many more ways. This Learn Python covers the following topics such as Python Basics, data types, control structures, functions and modules, exceptions working with files, functional programming, object-oriented programming and regular expressions

Pydroid 3

Pydroid 3 is for educational IDE for Python 3. Pydroid 3 is an easy tool to use and it is specially powerful educational IDE for python in Android.

For this mobile app, no internet is required to run Python programs and offline Python 3.6 interpreter is there for the particular task. This is a complete Tkinter support for GUI. This is built-in C, C++ and even Fortran compiler designed by n0n3m4, an author of C4droid, specially for Pydroid 3. It lets Pydroid 3 build any library from pip, even if it is using native code. We can build & install dependencies from a command line. PyQt5 support available in Quick Install repository along with matplotlib PyQt5 support with no extra code required.

As features of this editor we can mention following features. Code prediction, auto indentation and real time code analysis are there like in any real IDE. Extended keyboard bar is with the software with all symbols that a user needs to program in Python programming language. There are given themes and syntax highlighting can be seen as a feature which is most helpful for the user. This enhanced code navigation of the interface of the mobile app,

As hardware requirements at least 200MB free internal memory is required and 220MB+ is recommended.

Main goal of the Pydroid 3 is to help user learn Python 3 programming language, and the first priority is porting scientific libraries (so system-related libraries are ported only when they are used as dependencies of some other educational package).

Though we have above mentioned features and advantages with Pydroid 3, there are some problems with this online platform. Major problem that some users are experienced can be seen when installing libraries from QPython 3 QPypi internal repository, so consider it to be binary incompatible with Pydroid 3. If the user needs any libraries that cannot be built with Pydroid 3 user has to contact the developer directly and other binary repositories are likely to be incompatible as well.

CHAPTER 3 - ANALYSIS

3.1. Introduction

Requirement analysis is very important task of a project. This is the process of determining user expectations for this new system. Identification of functional requirements and non-functional requirements is necessary to fulfil the objectives of the project.

A software requirement is a capability needed by the user to solve a problem or to achieve an objective. In other words, requirement is a software capability that must be met or possessed by a system or system component to satisfy a contract, standard, specification, or other formally imposed documentation.

There are several activities with requirement analysis of a system such as eliciting requirements from different sources of the proposed system, analyzing requirements which are collected, requirements modeling with identified patterns and review and retrospective.

Functional Requirements are the things what has to be done by identifying the necessary task, action or activity that must be accomplished. Functional requirements analysis will be used as the top-level functions for functional analysis.

Non-functional Requirements are requirements that specify criteria that can be used to judge the operation of a system, rather than specific behaviors.

3.2. Target Audience

The audience of the system is required to be considered with analysis of the system. It is more important for the designer when design the system as he can design the system to cater all the requirements of particular parties.

According to this online system for practicing python programing, the main audience is students who follow ICT as a main subject for G.C.E. Advanced Level examination. And teachers who teach ICT for G.C.E. Advanced Level students also can use this system as a teaching tool to teach programming concept. Additionally, the students who are interested in learning programming concepts generally or who learns for individual requirements also use this system for their self-learning and practicing.

3.3. Data Collection Methods

Data collection is the process of gathering and measuring information on requirements of users of the proposed system. Different types of data collection techniques can be used to collect data of a system which is to be developed. Data collection methods are interviews, documents review, observation, questioning, measuring, prototyping or a combination of different methods. Collecting proper requirements is a main factor for analyzing requirements and do design the system well.

Data collection enables the designer to answer relevant questions and to evaluate outcomes of the project. Through data collection process it is easy for developers to make predictions about most of the probabilities and future trends of the proposed project.

Among different types of data collection methods as mentioned in the above, meetings with subject policy makers, interviews with selected teachers & students and observations made on written answer scripts for advanced level examination were used to capture requirements of this online system. Specially as a requirement gathering technique, prototyping is used to capture user's requirements more clearly of this online system for programming practices.

Interviews made with teachers and students were helps to get a clearer picture of the practical problem regarding programming concepts. Information gathered from meetings which were held with members of Nenasa and e-learning unit of Ministry of education were important to get an idea of providing a platform for practicing programming concepts. Observations made on written answer scripts for advanced level examination were helpful to collect real situation of students' answers for programming questions in the question paper.

Sample developments were made as a prototype to gather clear requirements of the system from teachers and students. Specially prototyping is more useful tool to get a clear picture on interface design from users. As students and teachers could see a working version on interfaces as users, they express their idea on changes in interfaces and framework on interfaces.

With all those above-mentioned requirements gathering methods which were used to gather requirements of this online system, summarizing and analyzing were done.

3.4. Functional Requirements

Functional requirements are any requirement which specifies what the system should do. These requirements describe the behavior of the system as it relates to the system's functionality. Functional requirements are services that the system should provide, how the system should react to particular inputs and how the system should behave in particular situations for the user.

According to this online system for programming practices, users expect particular sets of functions and through that we can mention direct requirements of the system. Functional requirements can be organized by use cases so that the main functions of the system will be understandable for developers.

Following requirements are identified as functional requirements of this system.

- F 1 - User shall be able to enter the python code through the interface.
- F 2 - User shall be able to see the output of the python code.
- F 3 - If runtime errors are occurred for the given code,
then the user shall be able to see those errors.
- F 4 - If the given code is executed correctly without errors,
the user shall be able to measure the quality of the code.
- F5 - User shall be able to download the given code as a python file.
- F6 - User shall be able to view and edit his earlier given python codes.
- F7 - User shall be able to download the python code
- F8 -User shall be able to login to the system

3.5. Non-functional Requirements

Non-functional requirements are any requirement which specifies how the system performs a certain function of the proposed system. These requirements elaborate a performance characteristic of the system.

Constraints on functions offered by this online system such as timing constraints, constraints on the development process, standards, etc. can be considered as a part of non-functional requirements. Non-functional requirements specify overall characteristics of the system which are expected through functional requirements of the system such as cost, reliability, accuracy, portability and etc.

Following requirements are identified as non-functional requirements of this online coding system according to the gathered requirements during the requirements gathering period.

Performance requirement

NF 1 - Performance of the system should be fast.

NF 2 - Performance of the system should be accurate.

NF 3 – System should be able to handle an expected and
non-expected errors without losing data.

NF 4 - System should be able to handle large programs.

Operational requirements

NF 5 - System should be Interoperable.

NF 6 - System should be user friendly

NF 7 – System should be easily access through internet.

3.6. Business Use case diagram

Business Use case diagram shows how this product is used by its customers and partners. It consists the activities which are directly concerned by the user, or member with internal process.

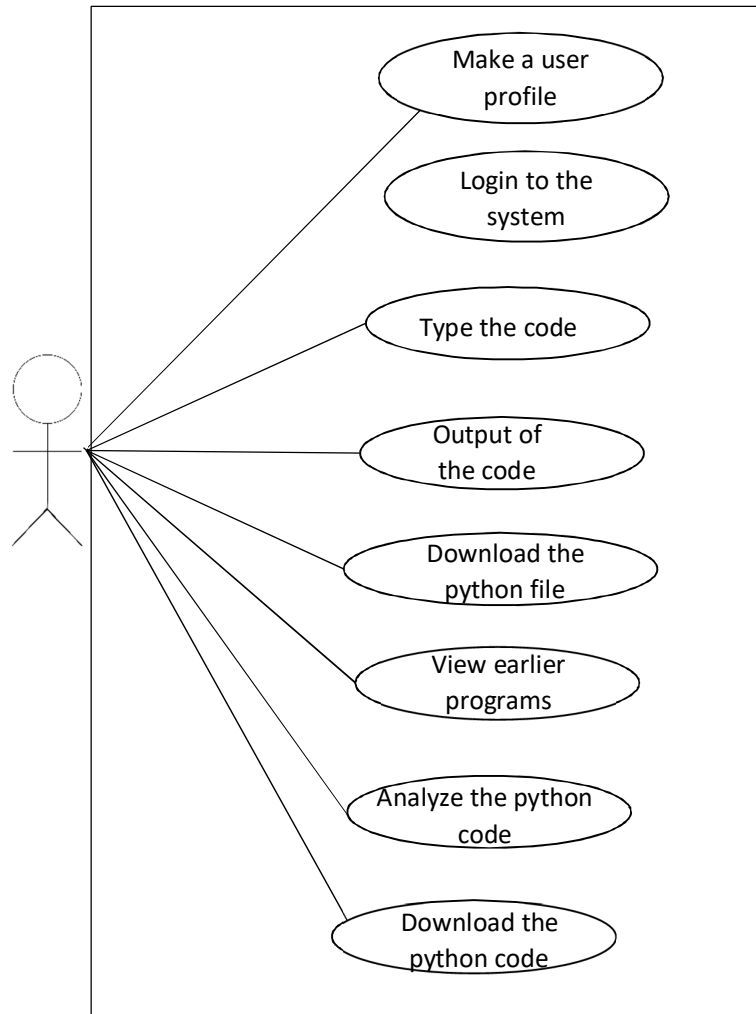


Figure 1 - Business Use case diagram

Figure 1 shows that the business use case diagram of this online system. According to the above diagram (figure 1 – business use case diagram), it explains that how user acts with the online system when he practices programming concepts.

According to the above diagram (Figure 1), user creates a profile for him and user will login to the system using his profile details such as username, password, email address and etc. When the user uses login function user enters into the system with his username and password. User enters the python code and get the result or error report. And the user can get the analysis report

on the python code entered in to the system and he can view earlier project codes which are practiced and by him. User can download any python code which is entered by him. *Figure 3* in the Chapter 4.2.1 shows that the conceptual use case diagram of this online system for python programming practices.

CHAPTER 4 - DESIGN

4.1 Introduction

Chapter 1.6 described the objectives of this online system for python programming. Sample design of the system is depicted by *Figure 2*

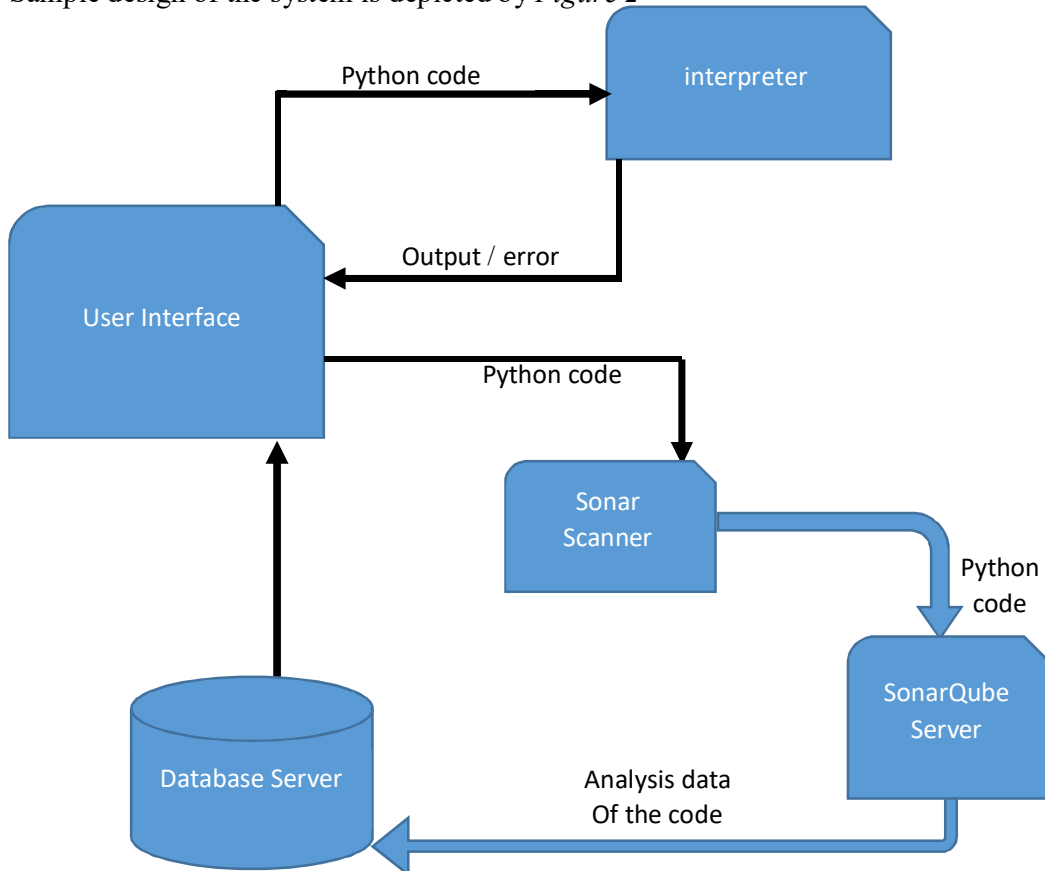


Figure 2-System Architecture

The major tasks of this system are allowing users for executing a python program, getting the output of the python code, showing errors of the code and analyzing the quality of the program.

First the python code is submitted to the system and the submitted program will be passed to python interpreter for the execution purpose. The interpreter will interpret the python code and respond with the result of execution for the submitted python code. If the result consists with errors, the user interface will display those errors for the user and if there are no errors, the user interface will display the output of the python code. This functionality will be done with interpreter.

When the user requested to analyze the python code, the code will be sent to the sonar scanner for scanning. Sonar scanner will convert the program to the form which is compatible with the SonarQube server. SonarQube server will analyze the program and it will store the analysis result in the database.

The analysis results include factors which are to be considered to check the quality of the python code. The entered python code is analyzed by the system with the support of ‘SonarQube’ which is the embedded third-party tool. These metrics are described in Annexures 2. Finally, the user interface will grab the selected analysis result from the database and show it to the user through user interfaces.

4.2. Conceptual Design

4.2.1. Use Case Diagram

Use case diagram helps us to summarize the details of our system's users (actors) and their interactions with the system. This shows scenarios in which the system or application interacts with people, organizations, or external systems when the user uses the online system.

According to the use case diagram identified with the online system for python programming, user creates his user account first, and then he can login to the system to practice with python programs. If user has logged in, then creation of a new project or loading of previously created project can be executed.

User may create new projects with a new name and project ID is given by the system automatically. User can load previously created python programs by which are created by that particular user profile. After user loaded or created a python program, he will do the python code submission and after submitting the code system will analyze and give the result. It will display errors if errors are available. And if there are no errors with the python code entered by the user he will get the output of the code as a result.

If the code entered by the user is executed without having errors, the code can be analyzed if user needs. Loaded python code or newly created python code is stored with the particular user profile and user can download the python code. And when user finished his work he may logged out.

These steps are explained in the following use case diagram in *Figure 3*.

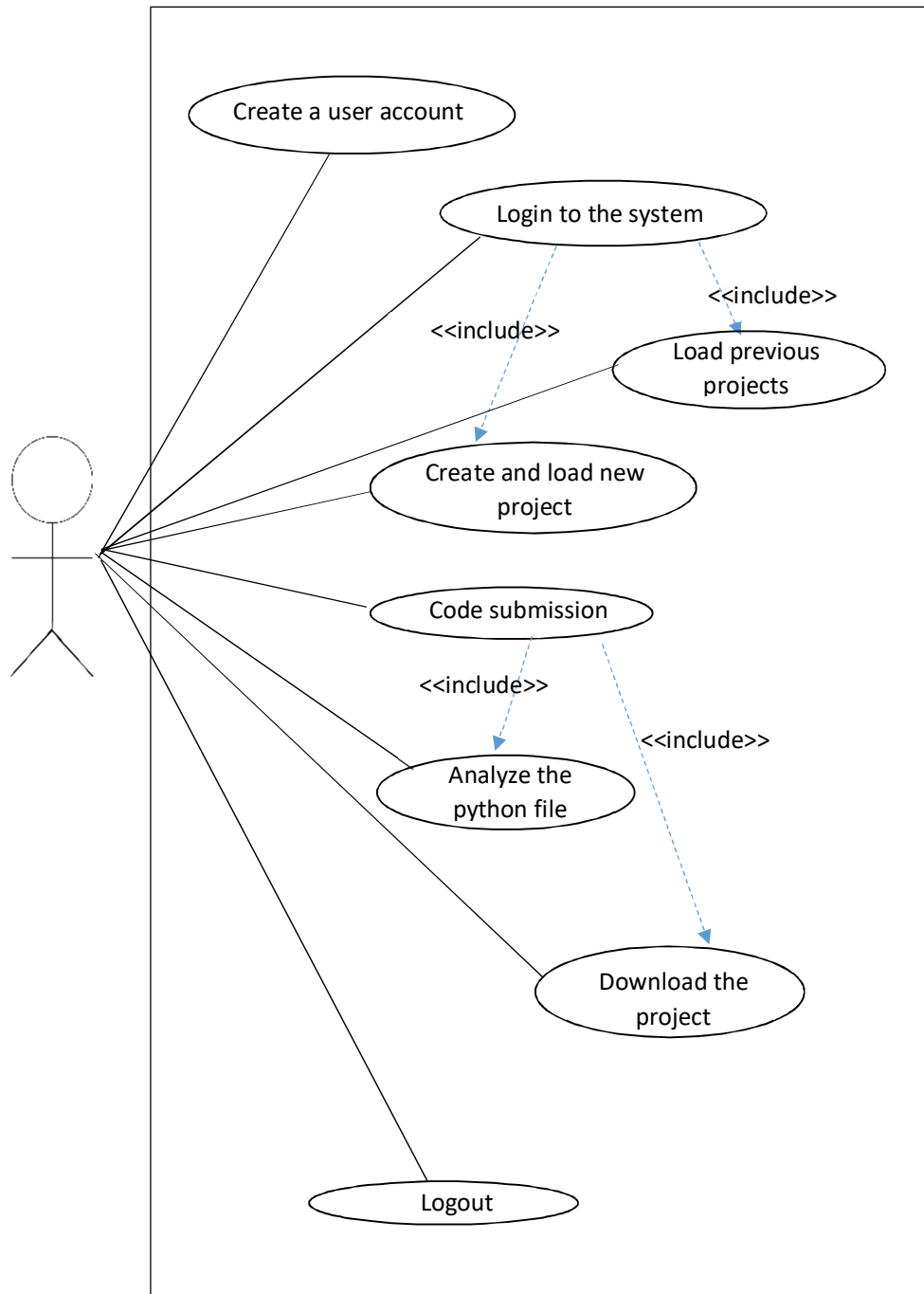


Figure 3- Use Case Diagram of the System

4.2.2. ER Diagram

An entity-relationship diagram (ERD) is used to represent the relationship between people, objects, places, concepts or events within that system graphically. This can be used to define entities and their attributes used in processes and can be used as the foundation for a relational database.

Following ER diagram shows only the entities and attributes of the system. This ER diagram does not include entities which are included in SonarQube environment.

According to the below ER diagram there are mainly two entities with the system. But with python background there are several other entities which are required for relations with each project. In this diagram I have included only main two entities and related attributes only. User will create many projects in Python programming. User and project are two. User will create many projects with his/her login, and one project is created only for one profile.

Each project of a user is identified by the id if the project and the project name will be given by the user. Each project has its owner which is taken from the user profile from the logged user details.

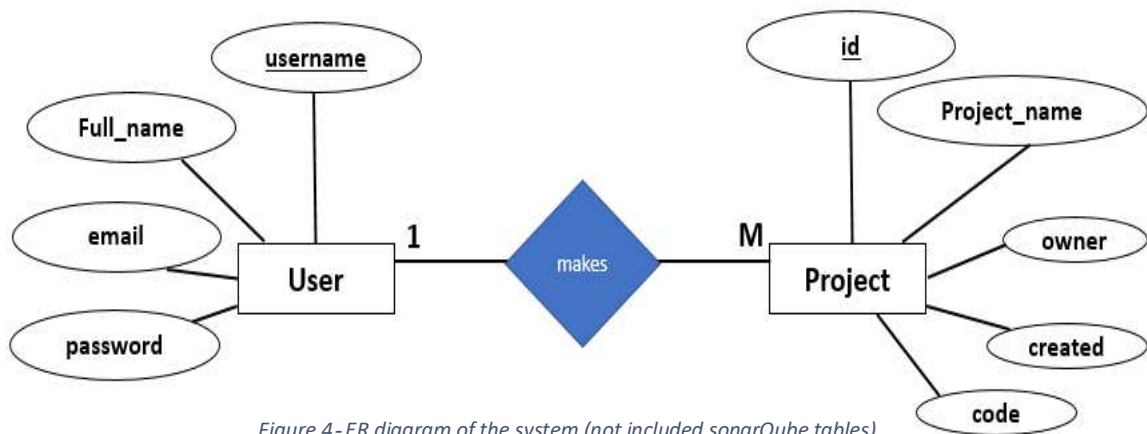


Figure 4- ER diagram of the system (not included sonarQube tables)

Only the ER diagram of the main system is shown in *Figure 4*. Each entity “**Project**” is connected with number of relations in SonarQube database. Relations in the SonarQube database will be shown in *Figure 5*.

With each project in the above-mentioned diagram, sonar relations are connected and they will be updated and store them with the relevant user's profile. With each analysis of a project, following tables are updated according to the relevant python project. The online system will produce analysis result from following tables (Figure 5)



Figure 5- Relations in the Sonar database

4.2.3. Interaction Diagram

Interaction diagrams describe how a group of objects of a system collaborate in some behavior specially a single use-case. The interaction diagrams show a number of example objects and the messages that are passed between these objects within the use-case.

Interaction diagrams come in two forms and both present in the UML. The first form is the sequence diagram. In this form objects are shown as vertical lines with the messages as horizontal lines between them. This helps us to illustrate how objects interacts via messages.

This diagram (*Figure 6*) shows a picture of control flow with nodes and it visualizes a sequence of activities. The diagram describes the interaction of user between identified objects within the system. This diagram describes that how this user send messages and which messages are passed through these objects.

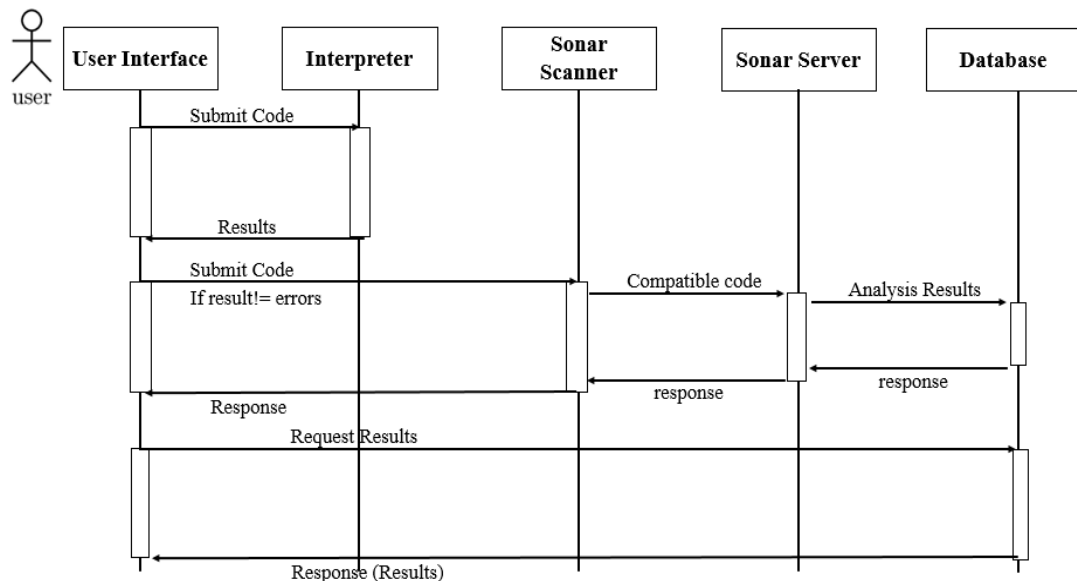


Figure 6- Interaction Diagram of the System

According to the below mentioned diagram, there are five objects which are collaborating with each other. They are user interface, Interpreter, Sonar scanner, Sonar scanner and database are collaborating. When user submits the code, it will be interpreted and the result will be sent back to the user through interface, with user and each other. When it is executed, the executed python code will be sent to the sonar scanner and through sonar server for analyzing part. For the above mentioned, analyzing results will be loaded into database and it will response through the sonar server.

4.3. User Interface Design

4.3.1 Introduction

User interface design is a major part of the design process and it is the front view of the system which the user sees. Most important part of any computer system is the Interface designing. When designing user interfaces, it is needed to consider more about the user friendliness. Because the interface is the system for most of the users. An effective and simple **user interface design** will be helpful for users to achieve their objectives with high efficiency.

System users often judge a system by its interface rather than its functionality. A poorly designed interface can cause a user to make catastrophic errors. And poor user interface design is the reason for so many software systems are never used.

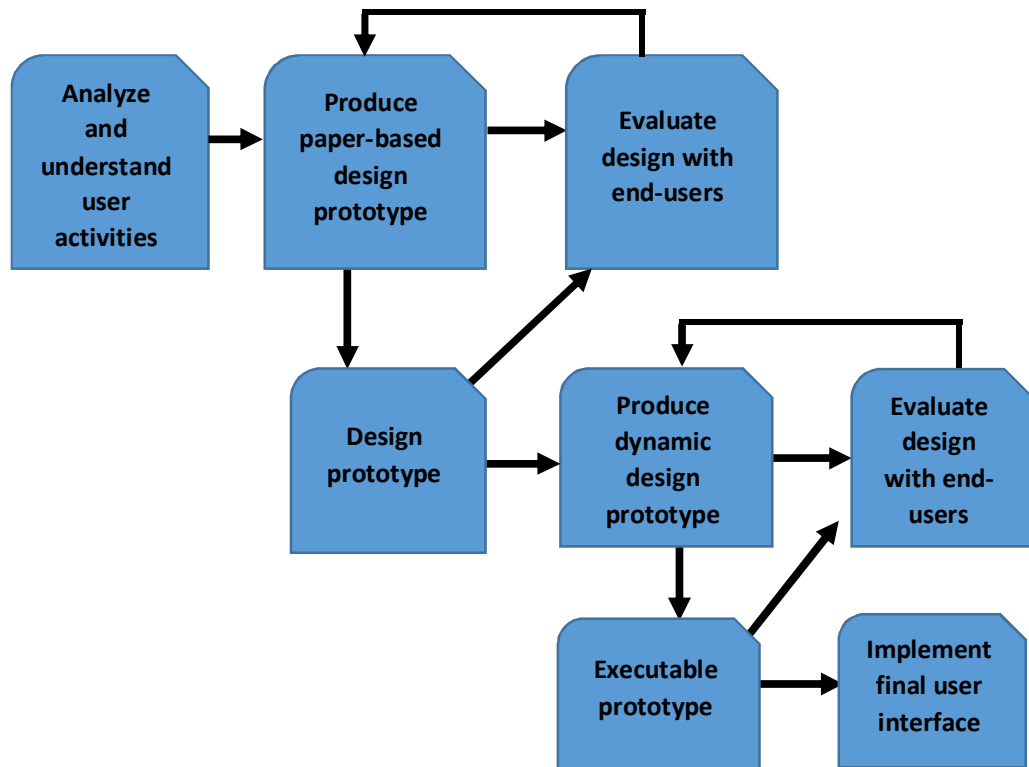


Figure 7- User Interface designing process

4.3.2 Interfaces

All the user interface designs of the online platform for python programming are given as follows.

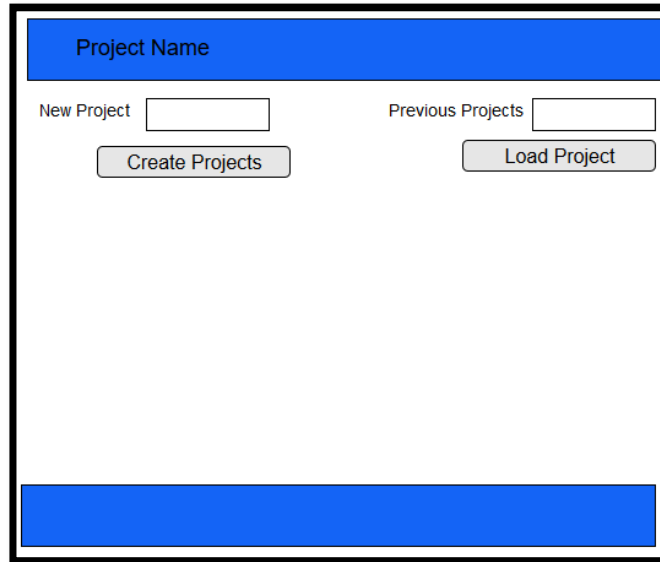
Interface Design - Home Page

The screenshot displays a web interface with a blue header bar at the top containing the text "Project Name". Below the header, there are two main sections: "Login" and "Sign up". The "Login" section includes a "Username" input field, a "Password" input field, and a "Sign in" button. The "Sign up" section includes a "Username" input field, a "Password" input field, a "Confirm Password" input field, a "First Name" input field, an "email address" input field, and a "Sign up" button. The entire interface is enclosed in a black border, and there is a blue footer bar at the bottom.

Figure 8-Interface Design - Home Page

This interface (*Figure 8*) is the interface which can be seen by any user when comes to the application first. New user can sign up with the system and a registered user can log in to the system through **Sign up** section of this interface (*Figure 8*). New user will create his account/ profile and the user will give required details for the creation of user profile through **Login** section of this interface. When the user is going to creates the profile, he will submit username, password, first name and email address to the database. If the user has already created his profile, then he can log in to the system with this username and password.

Interface Design - Create a Project

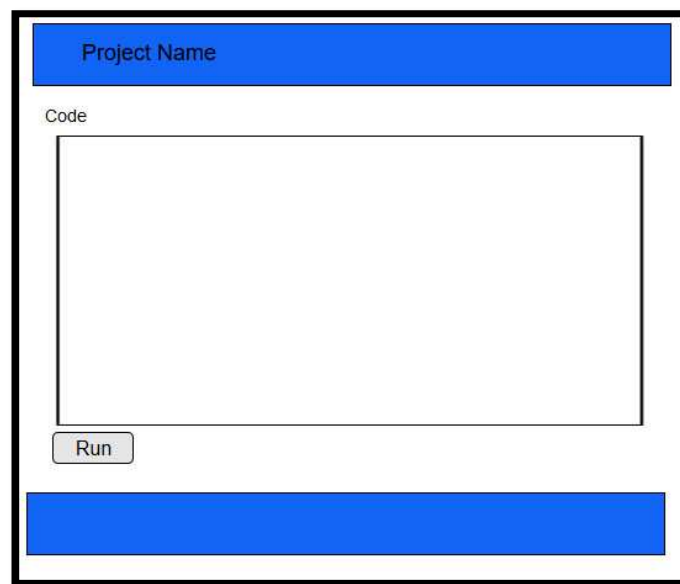


The screenshot shows a software interface for creating a project. At the top, there is a blue header bar with the text "Project Name". Below this, there are two input fields: "New Project" on the left and "Previous Projects" on the right. Under the "New Project" field is a button labeled "Create Projects". Under the "Previous Projects" field is a button labeled "Load Project". At the bottom of the interface is a solid blue horizontal bar.

Figure 9- Create a Project - Design

This interface (*Figure 9*) allows user to create or load a project. Using **New Project** option, he will create a new project by giving the project name. And If the user needs to open an already created project for editing or analysis purpose, user will select the required project through previous project option which loads all the created projects with that particular user profile. **Previous projects** option will show all the project name with ID.

Interface design - Create a Project



The screenshot shows a software interface for coding. At the top, there is a blue header bar with the text "Project Name". Below this, there is a label "Code" followed by a large, empty rectangular text area for entering code. At the bottom left of the text area is a button labeled "Run". At the bottom of the interface is a solid blue horizontal bar.

Figure 10-Interface Design - Coding Interface

Figure 10 is the interface which allows user to create the project. User can enter the python code in the editor part of this window. And any modification can be done through this editor by the user. Then the user will use the **Run** button to send this code and to interpret the python code. When user submit this project, then the output window will be displayed.

Interface design -Output error result

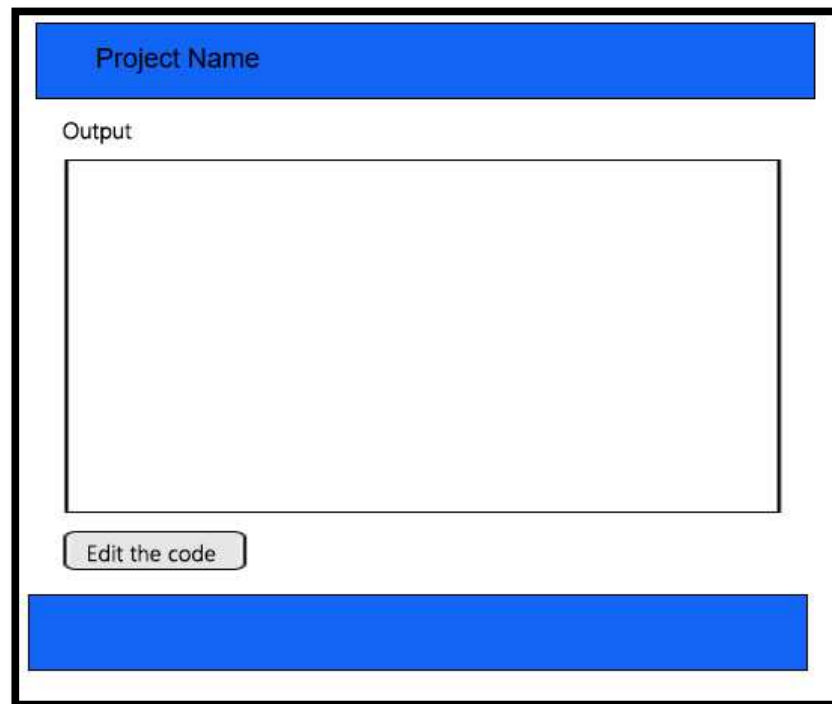


Figure 11- Interface design –Output error results

Figure 11 shows the result window of the online system for python programming. As it is described with *Figure 2*, When user submit the python code which is entered by the user for the execution, the code will be sent to the python interpreter. Then the interpreted python code will generate errors of the code if errors are available.

When errors are displayed on this screen with the relevant line number user is allowed to edit the code and there is an option to submit the modified python code through this interface.

Interface design -Output of the project

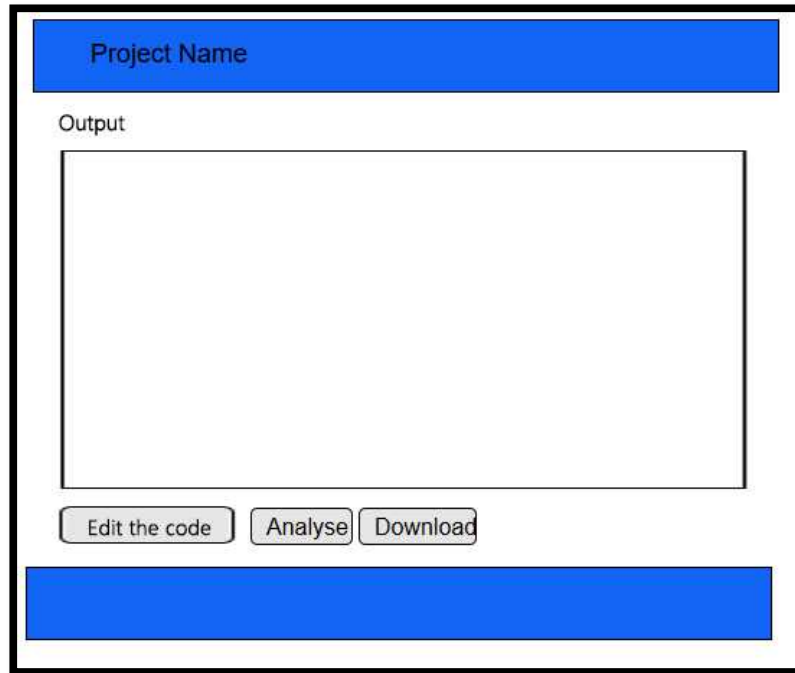


Figure 12 - Output of the code

Figure 12 shows the interface which contains result of the online system for python programming. As it is described with Figure 2, When the python code is submitted entered by the user for execution, the code will be sent to the python interpreter as it is described with Figure 2. Then the output of the python code will be displayed on the screen. This window will be executed, if the code has interpreted without having any error.

With this interface (Figure 12) user is allowed to edit the python code which is loaded into the editor and to send the python code for analysing purpose. If the user requires to download the project code/ python code for another usage, that the code can be downloaded through this interface. From this interface (Figure 12), user can download the python code as a python file into his personal computer.

Interface design -Analysis Result

The diagram shows a web interface layout. At the top is a blue header bar containing the text "Project Name". Below the header is a large white rectangular area labeled "Output". Underneath the "Output" area are three buttons: "Edit the code", "Analyse", and "Download". Below the buttons is another large white rectangular area labeled "Analysis result". At the bottom of the interface is a solid blue horizontal bar.

Figure 13 - Analysis result

Figure 13 shows the interface which is loaded the output of the python code. This interface will load the python program which is interpreted without having any problems. The user is allowed to edit the code if user needs. And he can analyse the code through **Analyse** option and the user can download the python code through the **Download** option.

And the above diagram (Figure 13) shows the analysis result such as code quality, duplicated lines, code smell and etc. From this interface (Figure 13) also, user can download the python code as a python file into his personal computer.

CHAPTER 5 - IMPLEMENTATION

5.1. Tools and Technologies Used

5.1.1 Introduction

Mainly there are two parts in this system. The first part is user interfaces and they are designed with HTML, CSS and JavaScript with the support of Bootstrap framework. Apache 2.4 is running as the file server and PHP language is used as the server-side programming language.

The next part is the analysing part and The JSP based SonarQube server and sonar scanner add-on is used for the analysis part. The user records, project records and the analysis records are stored in a MySQL database.

5.1.2 Use of SonarQube

There are 4 components in SonarQube Platform as SonarQube Server, SonarQube Database, SonarQube Plugins and SonarQube Scanner.

SonarPython covers some well-established quality standards. The SonarPython capability is available in Eclipse and IntelliJ for developers (SonarLint) as well as throughout the development chain for automated code review with self-hosted SonarQube or on-line SonarCloud.

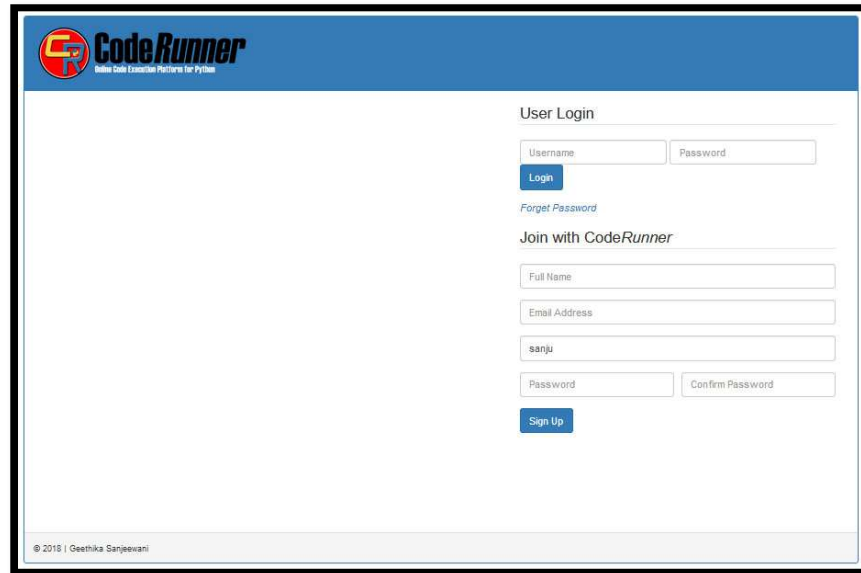
SonarQube Server processes with 3 main servers as web server, search server and Compute Engine Server. SonarQube Database stores configuration of projects and quality views. SonarQube Scanners running on your Build / Continuous Integration Servers to analyse projects. Sonar Python plugin is used for analysing python codes. By default, the Python Plugin will execute for you the pylint command.

Source code of the project is sent from the server to the analyser and then the files provided to the analyser are analysed. In the form of a report, analysis result is sent back to the server at the end.

5.2. User Interfaces

This chapter explains about real user interfaces which are implemented with the system. Home page, Editor page, analysis page and other interfaces are described in this area.

Home page

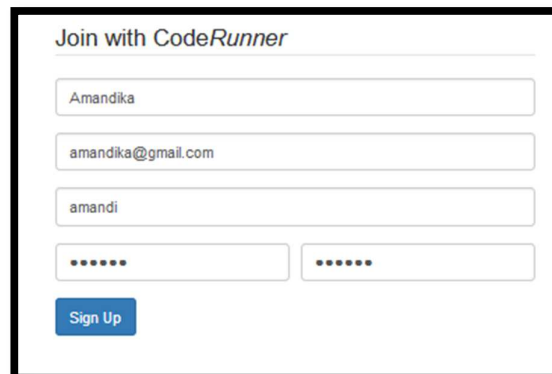


The screenshot shows the CodeRunner website's home page. At the top left is the CodeRunner logo with the tagline "Online Code Execution Platform for Python". The main content area is divided into two sections. The "User Login" section contains a "Username" input field, a "Password" input field, a blue "Login" button, and a link for "Forgot Password". Below this is the "Join with CodeRunner" section, which includes a "Full Name" input field, an "Email Address" input field (containing "sanju"), a "Password" input field, a "Confirm Password" input field, and a blue "Sign Up" button. At the bottom left of the page, there is a copyright notice: "© 2018 | Geethika Sanjeevani".

Figure 14 - Home page

This is the interface (Figure 14) which any user (new / registered user) can use for signup and sign in purpose. It is the interface which can be seen any user when comes first.

Signup a user



This is a close-up view of the "Join with CodeRunner" sign-up form. It features five input fields: "Full Name" (containing "Amandika"), "Email Address" (containing "amandika@gmail.com"), "Username" (containing "amandi"), "Password" (masked with dots), and "Confirm Password" (masked with dots). A blue "Sign Up" button is positioned at the bottom left of the form.

Figure 15 - Home page - Sign up section

If the user is a new user for the system, Figure 15 is there to fill required data to be filled by the user.

Login

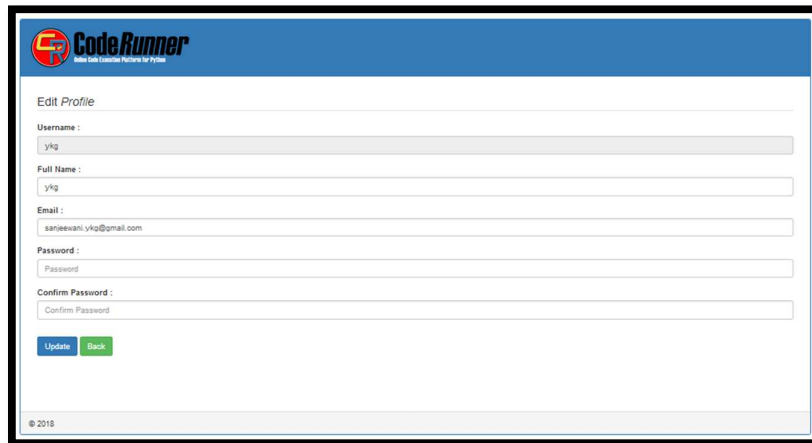


The image shows a 'User Login' form. It has a title 'User Login' at the top. Below the title, there are two input fields: one for the username containing the text 'sanju' and one for the password containing ten dots. A blue 'Login' button is positioned below the username field. At the bottom of the form, there is a link that says 'Forget Password'.

Figure 16 - Home page –Login section

Figure 16 is for the user to login to the system when already registered user is there.

Edit Profile

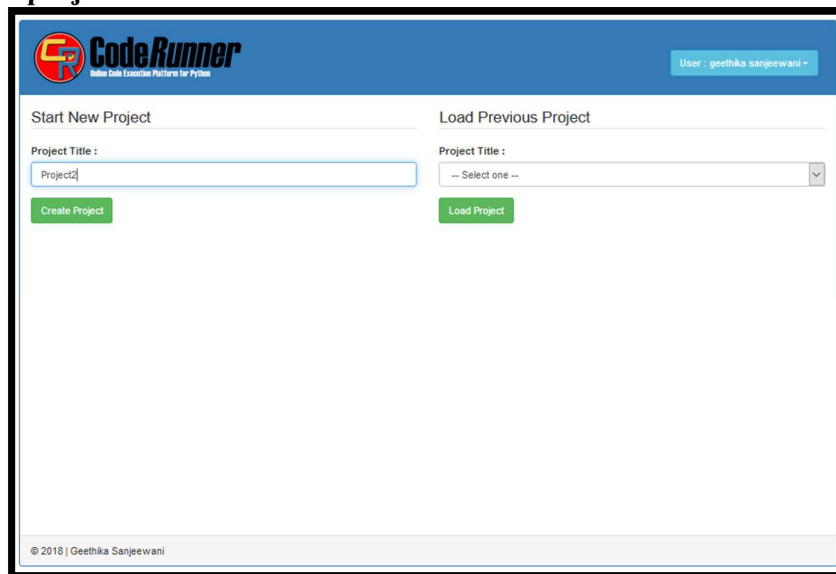


The image shows an 'Edit Profile' form. At the top left is the 'CodeRunner' logo with the tagline 'Online Code Execution Platform for Python'. The form title is 'Edit Profile'. It contains several input fields: 'Username' with 'ykg', 'Full Name' with 'ykg', 'Email' with 'sanjeevani.ykg@gmail.com', 'Password', and 'Confirm Password'. At the bottom left of the form are two buttons: 'Update' (green) and 'Back' (green). The footer of the page says '© 2018'.

Figure 17 - Edit profile

When a registered user needs to edit his profile, the above mention interface (Figure 16).

Create a project



The image shows a 'Create a project' form. At the top left is the 'CodeRunner' logo. In the top right corner, there is a user profile indicator that says 'User: geethika sanjeevani'. The form is divided into two main sections: 'Start New Project' and 'Load Previous Project'. Under 'Start New Project', there is a 'Project Title' input field with 'Project2' entered and a green 'Create Project' button. Under 'Load Previous Project', there is a 'Project Title' dropdown menu with '-- Select one --' and a green 'Load Project' button. The footer of the page says '© 2018 | Geethika Sanjeevani'.

Figure 18 - Create a project

When a user logged in to the system, this interface (*Figure 16*) will be appeared. I the user needs to create a project, he will use **Start New Project** section and he will give the project title. Using the given project title, new project will be created within the particular user's folder. Then the interface will be changed into the interface which shows the python code as shown in *Figure 18* (Editor Page).

If the user has created projects earlier and that user needs to open an previously created python code he can use **Load Previous Projects** option. Through that option, user can load previous projects and select the project that he needs to open. Then the interface will be changed into the interface which shows the python code as shown in *Figure 18* (Editor Page).

Editor Page

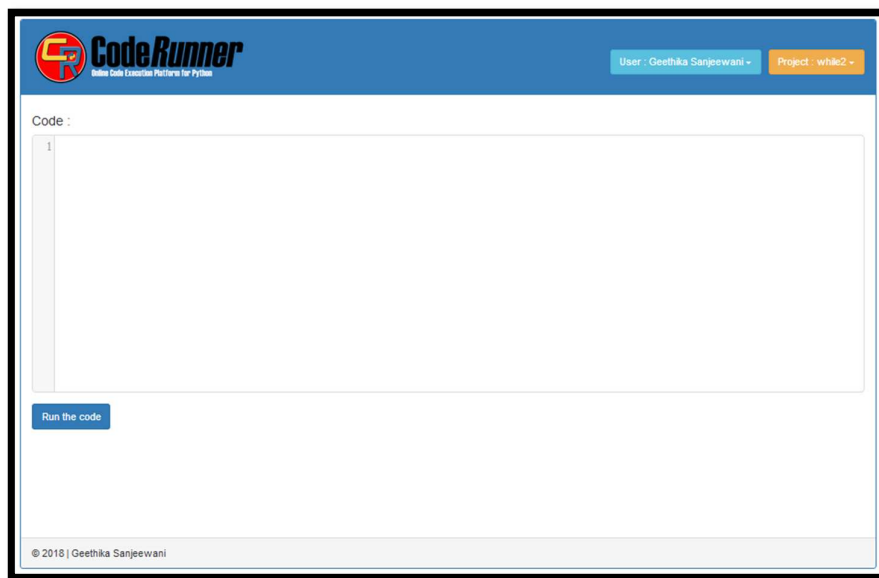


Figure 19 - Editor Page

This interface allows user to create or edit the python code. User will finalize the python code and he will use **Run the code** option for interpreting purpose. Line numbers will be shown with the editor and user can enter the python code with alignments. When user runs the code, then the copy of the code will be stored in the particular user profile folder.

Python code with the interface

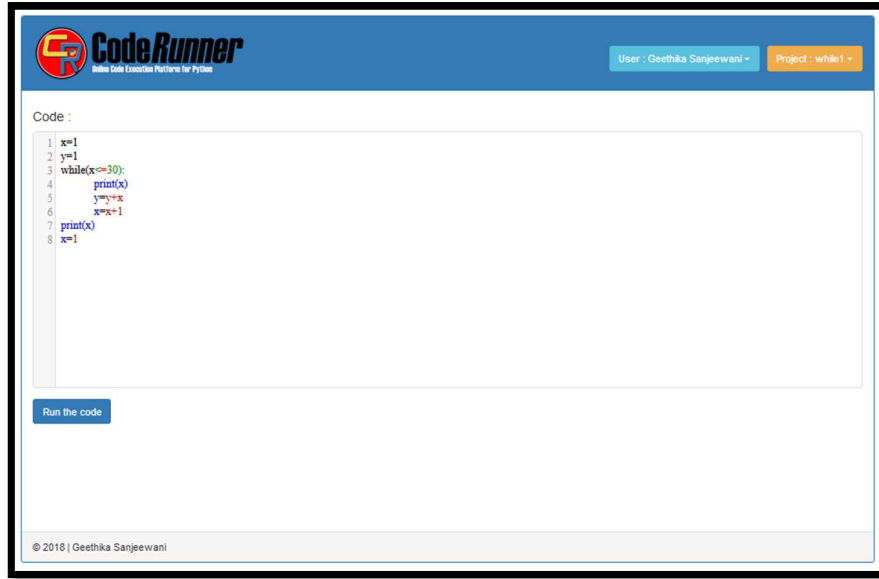


Figure 20 - Python code in the editor

When the user enters the python code with errors, code will be displayed in the editor as mentioned in the *Figure 20*.

Results of the code

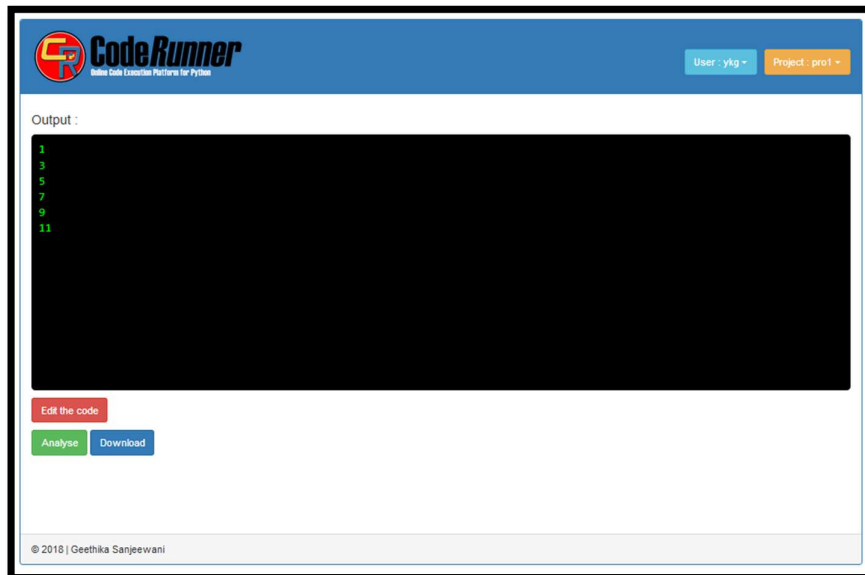


Figure 21 - Result of the code

When the user enters the python code, the result of the interpreted python code will be displayed as mentioned in the *Figure 21*.

Python code with an error result

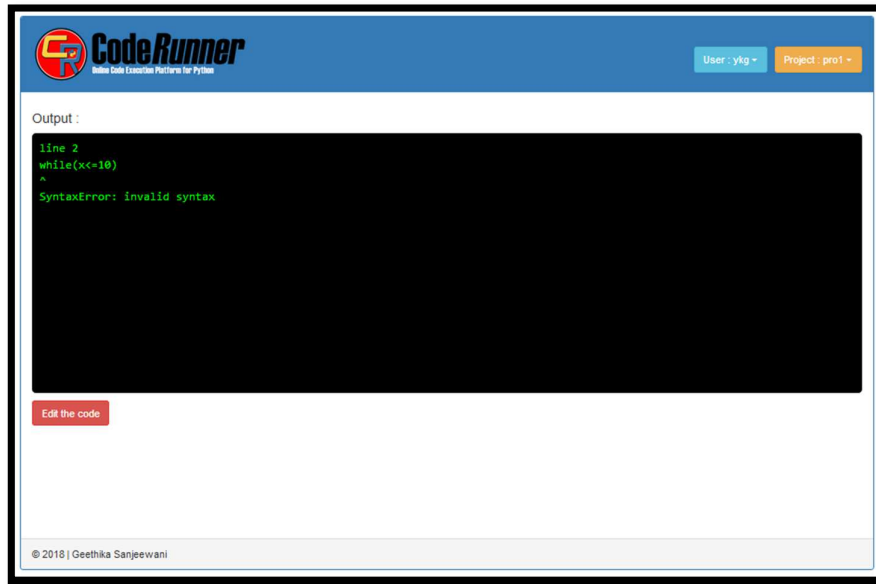


Figure 22 - Error result of a Python code

When the user enters the python code, error result will be displayed in the screen as mentioned in the Figure 22.

Python code with input data

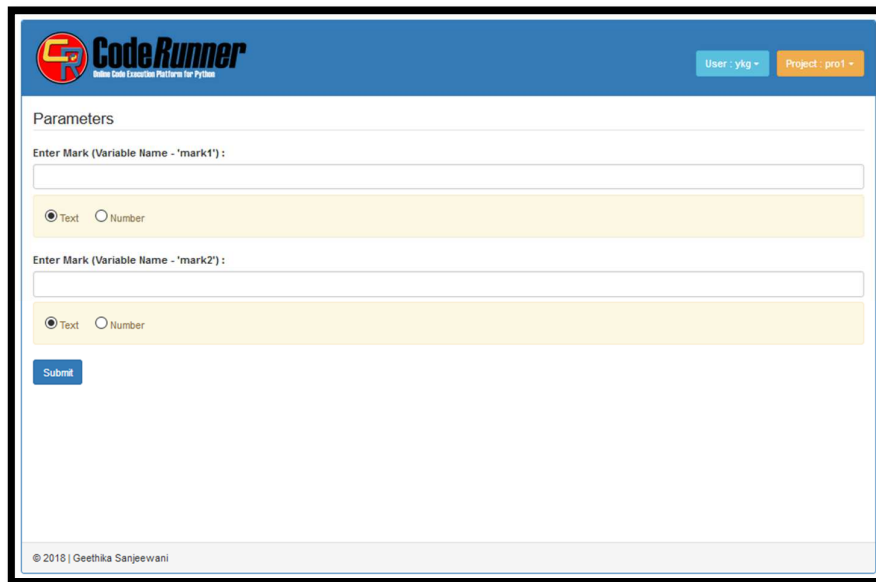


Figure 23 - Python code with input data

The user can include input values with the editor interface (Figure 20). But the user may require a value to be entered into the system. For that users have to enter a value through the above-mentioned interface (Figure 23). Data type for the value can be selected through this interface.

Executed code (Analysis option available)

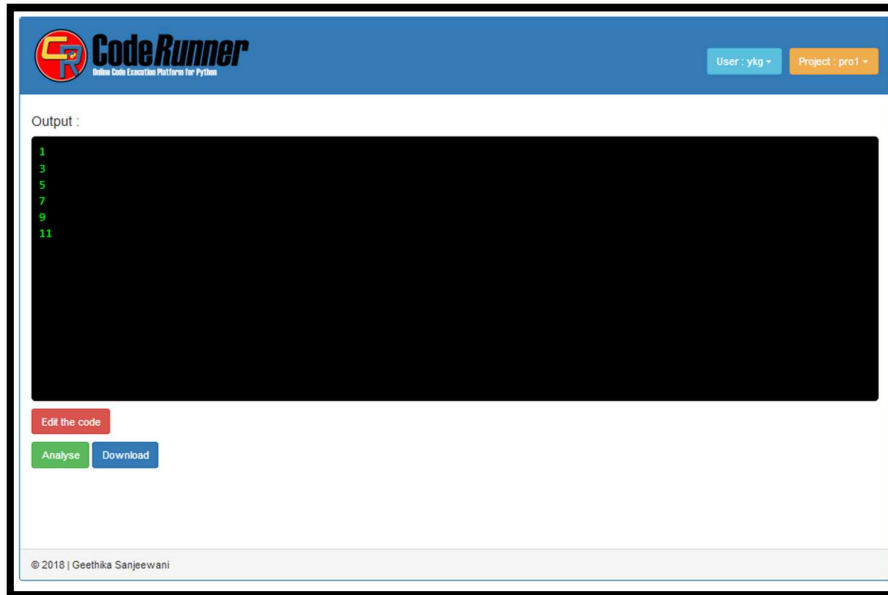


Figure 24 – Executed code (Ananalysis option available)

Analysis results

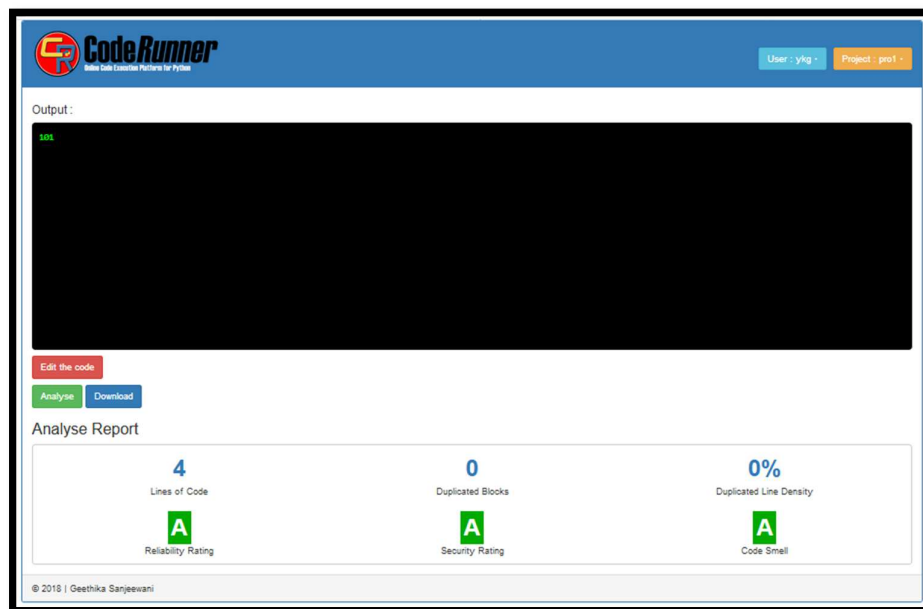


Figure 25 - Analysis results window

Figure 25 shows the quality of the python code submitted by the user. These qualities are generated from Sonar database for each project which is to be analysed. As qualities of a python code, **Lines of Code**, **Duplicated blocks**, **Duplicated Line Density**, **Reliability rating**, **Security rating** and **Code smell** are included. These matrices are described in *Annexure 2*.

Download a python file

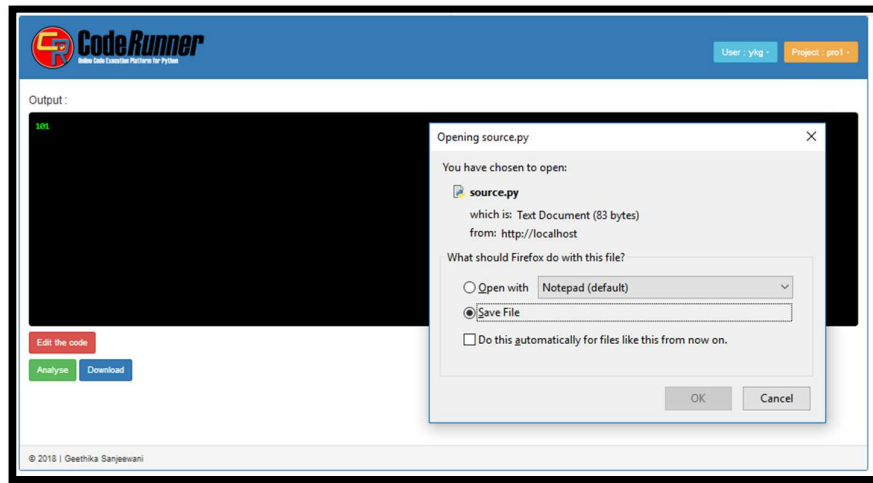


Figure 26 – Download a python file

As mentioned in the *Figure 26*, user can download the python code which can be stored in a particular user profile.

CHAPTER 6 – TESTING PLAN

6.1. Introduction

Software Testing is evaluation of a software against requirements gathered and system specifications. Testing is conducted at the phase level in software development life cycle or at module level in program code. Testing is one of the most important parts of any application design and implementation

Software testing can be done in two ways such as manually or using an automated testing tool. Software tester can use test cases for identified sections and modules. Testing results can be taken by executing prepares test cases with test data. Automated testing is a procedure with the help of automated testing tools.

Testing stage of a system can be divided into two main sections such as User Interface Testing and Functionality Testing. It is very important to know the main requirement for testing and what kind of tests do we need to carry out in order to assure the quality.

The main objective of testing is that the quality assurance for a bug and usability issue free application/system. The other objective of testing an application before it is in use for all is to be cost effective. The issues found in application untested in early phases are expensive to resolve than those found and resolved before publishing. A tested solution with known issues is always better than untested ones without problems.

This document describes the plan to test the online platform to enhance programming practices.

6.2. Testing process overview

This test plan document supports objectives such as identification modules to be tested, list out test requirements, identification of test cases and execution of testing process.

Testing process of the system does not go one after another. There can be parallel tests ongoing along with development and other tests. Testing process design is a well-documented design plan containing way on how to proceed with testing or in other ways how to test the created solution.

Planning of testing process is a very important step in testing process. It determines how much in flow the whole process goes. Test process design with improper planning lead to failing applications. There are certain elements which should be planned before moving to actual tests such as use cases, user representative, user observation, questionnaires, interviews.

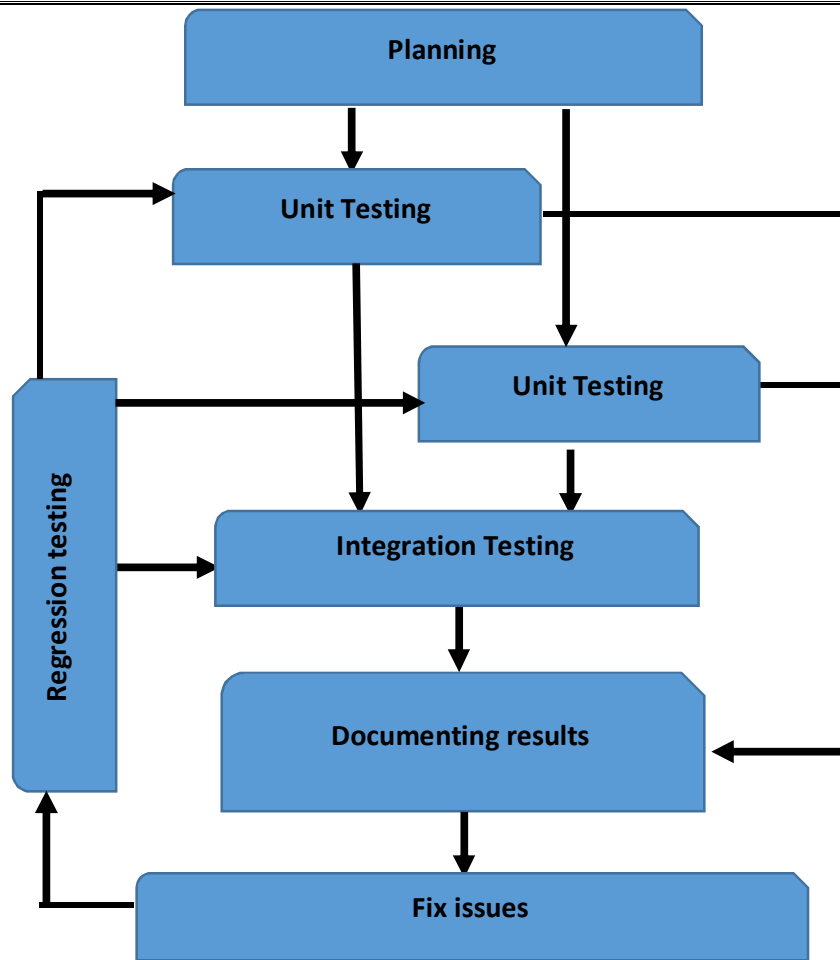


Figure 27 - Testing Process Overview

The above diagram (*Figure 27 – Testing Process Overview*) shows the connection between each testing step. The arrows show the inter-connectivity between each testing step. And it shows how most of the steps are not just occurring after completion of one but are occurring simultaneously or in a parallel manner. Unit testing and interface testing can be done at the same time without waiting for others to finish. They do not need to be waiting for another to finish first. On opposing, in order to carry out integration tests, part of both unit tested result and interface tested results are needed.

It is also possible to skip out unit and interface testing and directly jump into integration tests but this will end up in pretty complex test scenario as all smaller tests that have been done on other two should be repeated here. The chances are testing will never get done or full proof results are hard to obtain. Fixing of errors of the module and integration, are done until the user gets the satisfaction or until it satisfied previously identified requirements. This document describes the plan to test the online platform to enhance programming practices.

This test plan document supports the following objectives

- Identify modules to be tested
- List test requirements
- Identify and describe test cases
- Describe execution of testing process
- List deliverables of test execution
- Test user's expectations

6.2.1. Identify modules to be tested

Identification of modules describes units of the system which are to be tested. Unit testing includes testing the features and functional logic of an application usually during the process of development of the system. Smallest block of functionalities and features of the application are isolated from other functionalities and features and tested separately and seen how they work individually.

This testing part is very important to check all the errors in the module including logical and syntax errors. With this module testing we can conduct white box testing where we can check the internal operations and the code of the identified module.

Followings are identified modules to be tested.

- T1 - User registration
- T2 - Login Process
- T3 - Execute the python code
- T4 - Measure the quality of code
- T5 – Download the file

6.2.2. Prepare test cases**T1 - User registration**

User registration is to be tested with successful registration with correct data and failure with errors which are made by users. User will try to register with identified error situations such as incorrect data format, incorrect data types, blank fields and etc. Following test cases are to designed to check the above-mentioned situations of user registration.

T1-1 User registration (Successful Registration)

Test ID	- T1-1
Title	- User Registration (Successful Registration)
Description	- Guest user can register with the system using the registration window.
Pre-condition	- The index page should be loaded in a supported web browser.
Assumption	- User has entered all the data in the correct way.
Test steps	<ol style="list-style-type: none">1. Enter form inputs to the registration process (First name, Email address, username. Password, confirm password)2. Click on “Sign Up” button.
Expected results -	<ol style="list-style-type: none">1. “Successfully Registered” Message2. Send an email which is given by the user by confirming about the user registration.

T1-2 User registration (blank field/fields)

Test ID	- T1-2
Title	- User Registration (Incorrect data)
Description	- Guest user can register with the system using the registration window.
Pre-condition	- The index page should be loaded in a supported web browser.
Assumption	- User has entered all the data except one or more Fields (blank fields are given)
Test steps	<ol style="list-style-type: none">1. Enter form inputs to the registration process (Some fields only)2. Click on “Sign Up” button.
Expected results	1. “ Please fill out this field ” Message

T1-3 ***User registration (Incorrect data – email address)***

Test ID	- T1-3
Title	- User Registration (Incorrect data – email address)
Description	- Guest user can register with the system using the registration window.
Pre-condition	- The index page should be loaded in a supported web browser.
Assumption	- User has entered all the data and email address is not in the correct format.
Test steps	<ol style="list-style-type: none">1. Enter form inputs to the registration process (email address is not in the correct format)2. Click on “Sign Up” button.
Expected results -	<ol style="list-style-type: none">1. “Please enter an email address” Message

T1-4 ***User registration (mismatched password)***

Test ID	- T1-4
Title	- User Registration (mismatched password)
Description	- Guest user can register with the system using the registration window.
Pre-condition	- The index page should be loaded in a supported web browser.
Assumption	- User has entered all the data and password is not matched with re-entered password.
Test steps	<ol style="list-style-type: none">1. Enter form inputs to the registration process (Password and confirm password are different)2. Click on “Sign Up” button.
Expected results -	<ol style="list-style-type: none">1. “Password mismatched” Message

T1-5 ***User registration (Entered username/email)***

Test ID	- T1-5
Title	- User Registration (repeated username/email)
Description	- Guest user can register with the system using the registration window.
Pre-condition	- The index page should be loaded in a supported web browser.
Assumption	- User has entered a username/ email address which is already used for another user.
Test steps	1. Enter form inputs to the registration process (username/ email address which is already used) 2. Click on “ Sign Up ” button.
Expected results -	1. “ Entered data incorrect ” Message

T2 – Login Process

Login Process (Successful Login)

Test ID	- T2-1
Title	- Login Process (Successful Login)
Description	- User can login to the system with username and password Which are given for user registration.
Pre-condition	- The index page should be loaded in a supported web browser.
Assumption	- User has entered correct username and password.
Test steps	1. Enter username and password in the correct text boxes. 2. Click on “ Sign In ” button.
Expected results -	1. Home page is loaded which contains space given for entering the code.

Login Process (incorrect password)

Test ID	- T2-2
Title	- Login Process (incorrect password)
Description	- User can login to the system with username and password Which are given for user registration.
Pre-condition	- The index page should be loaded in a supported web browser.
Assumption	- User has entered correct username and incorrect password.
Test steps	1. Enter username and password in the correct text boxes. 2. Click on “ Sign In ” button.
Expected results -	1. “ Password entered is incorrect ” Message

Login Process (incorrect username)

Test ID	- T2-3
Title	- Login Process (incorrect username)
Description	- User can login to the system with username and password Which are given for user registration.
Pre-condition	- The index page should be loaded in a supported web browser.
Assumption	- User has entered correct username and incorrect username.
Test steps	1. Enter username and password in the correct text boxes. 2. Click on “ Sign In ” button.
Expected results -	1. “ Incorrect username ” Message

T3 – Execute a python code

Execution of a python code is another module to be tested. The code will be interpreted by the python interpreter. Through this test case, it will check whether the code with errors is identified by the system and whether the system can display them to the user. If the user has entered the code without syntax errors, it must be checked and displayed the output of the given python code.

Following test cases show above mentioned situations. Test case T3-1, successful code will be tested and using test case T3-2, a python code with error will be tested

Execute a python code (Successful code)

Test ID	- T3-1
Title	- Execute a python code (Successful code)
Description	- User enters the python code in the editor section. When he submits the code, it is interpreted and give the output/error.
Pre-condition	- User has logged into the system and loaded the editor page.
Assumption	- Targeted group of this online system is G.C.E. Advanced level students who study ICT as a subject. Therefore, following are considered to be tested in the python code. Sequence of instructions / Variables / While loop / Repeat until / For do / lists / arrays / tuples/
Test steps	1. User enters the python code. 2. Click on “ Run ” button.
Expected results -	Output of the code is displayed on the output area.

Execute a python code (Code with error)

Test ID	- T3-2
Title	- Execute a python code (Code with error)
Description	- User enters the python code in the editor section. When he submits the code, it is interpreted and give the output/error.
Pre-condition	- User has logged into the system and loaded the editor page.
Assumption	- Targeted group of this online system is G.C.E. Advanced level students who study ICT as a subject. Therefore, following are considered to be tested in the python code. Sequence of instructions / Variables / While loop / Repeat until / For do / lists / arrays / tuples/
Test steps	1. User enters the python code. 2. Click on “ Run ” button.
Expected results -	Error will be displayed on the output area.

T4 – Analyze the python code

Measure the quality of the python code

Test ID	- T4-1
Title	- Measure the quality of the python code
Description	- User can see the quality of the python code entered. User can see number of lines in the codes, duplicated blocks/ duplicated line density/ security rating/ code smell/ etc.
Pre-condition	- User has logged into the system and entered python code has been executed without any error.
Assumption	-
Test steps	1. Click on “ Analyze ” button.
Expected results -	Analysis result is displayed on the screen.

6.2.3. Identifies User's Expectation (Acceptance Testing)

An acceptance test of a system can be understood as a way to check if a previously defined “contract” between the developer and the customer is still on track. Running those acceptance tests also ensures the developer that no requirement change has happened in the meantime and that everything is as it should be to satisfy the customer. It is important to get user's satisfaction of an online system for practising python codes with the online system for python programming.

About the user satisfaction of a system can be measured using several types of testing. The following User Acceptance Testing Types can be used for the above requirements.

- Alpha & Beta Testing
- Contract Acceptance Testing
- Regulation Acceptance Testing
- Operational Acceptance Testing
- Black Box Testing

To identify the user satisfaction of this online system, set of students and teachers were in the testing procedure. According to their experiences, a given questionnaire was completed. Questionnaire is attached as *Annexure 1*.

CHAPTER 7 – CONCLUSION

The CodeRunner is implemented as an online tool to enhance the students' skills in programming with python. Since this tool is an online tool, it can be used with a web browser without installing any other software or plugins.

The students are motivated to use this tool because they haven't a pre-requested task to be done to use this and they can think only about programming rather than thinking about installations and configurations.

Although configuring and using a code analyzing and quality evaluation tool such as SonarQube is very difficult for students, the students can use that tool in a user-friendly and very simple manner with code runner. Since all the processes are done as background server-side processes, the students are attracted by the simplicity of this system very much. Students will practice their python codes through Code Runner with good practices in programming as they can analyze their codes.

In order to develop this online system, numbers of technologies were used such as PHP, HTML, JavaScript, MySQL and CSS. The project was finished meeting the user expectations which are gathered through meetings, observations, discussions made with teachers, students and members of members of ministry of education. User feedback was positive and they found the system easy to use and extremely helpful for their self-learning.

Through this code validation system, it can be achieved that “Develops algorithms to solve problems and uses python programming language to encode algorithms” which is the competency of the chapter “Programming Concepts” in G.C.E. (Advanced level) syllabus.

CHAPTER 8 – FUTURE ACTIVITIES

- **Provide a mobile application**

Mobile application can be provided which interacts with the remote web server. Then students will be able to access easily through any device. Students will be able to quickly connect with the system when they have a mobile application and system will be able to increase the level of accessibility.

- **Support the system with conceptual diagrams.**

System can be modified to allow students to practice programming with extra support of conceptual diagrams such as flow charts. Students will be able to draw flow chart for a given problem before practice with python programming.

- **Provide localized environment for students**

Currently this system is running only with English medium. This system can be localized with other languages such as Sinhala and English which they are familiar with. Then students will be able to work with more user-friendly environment.

- **Provide a tutorial set with the system**

Tutorial set which can cover all the concepts of programming for students can be given to practice with this Code Runner system. Then students will be able to have a guide to continue their practices and students can use them as a self-learning tool. Teachers will be able to use tutorial set as a teaching aid for their teaching process.

- **Provide an adaptive learning environment**

This system can be used to identify the level of the student regarding his knowledge on programming. Then according to the level of the student, set of activities can be given to the student to improve the knowledge. Then the student will be able to learn with this system at their own speed.

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ANNEXURES

Annexure 1

CodeRunner - Online Python Evaluator

User Satisfaction Survey

Position – Teacher / Student

Date -.....

(Put ✓ mark inform of the option according to your experience.)

1. This system is very much helpful in practicing programming concepts with python.

Strongly agree		Agree		Neutral		Disagree		Strongly disagree	
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2. Working with online tool without installing and configuring the language encourages practicing python.

Strongly agree		Agree		Neutral		Disagree		Strongly disagree	
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3. Managing user profiles with the projects is useful.

Strongly agree		Agree		Neutral		Disagree		Strongly disagree	
----------------	--	-------	--	---------	--	----------	--	-------------------	--

4. Practicing python with a code inspection tool is very much helpful.

Strongly agree		Agree		Neutral		Disagree		Strongly disagree	
----------------	--	-------	--	---------	--	----------	--	-------------------	--

5. Using a code inspection tool like SonarQube without a heavy configuration process is very beneficial.

Strongly agree		Agree		Neutral		Disagree		Strongly disagree	
----------------	--	-------	--	---------	--	----------	--	-------------------	--

6. The user interfaces of the system are on a satisfactory level.

Strongly agree		Agree		Neutral		Disagree		Strongly disagree	
----------------	--	-------	--	---------	--	----------	--	-------------------	--

7. System provides quick responses for requests made by the user.

Strongly agree		Agree		Neutral		Disagree		Strongly disagree	
----------------	--	-------	--	---------	--	----------	--	-------------------	--

8. I can perform well on the exercises in the python program?

Strongly agree		Agree		Neutral		Disagree		Strongly disagree	
----------------	--	-------	--	---------	--	----------	--	-------------------	--

9. I could adapt with the system quickly.

Strongly agree		Agree		Neutral		Disagree		Strongly disagree	
----------------	--	-------	--	---------	--	----------	--	-------------------	--

10. I could practice with number of exercises to be familiar with python programming language.

Strongly agree		Agree		Neutral		Disagree		Strongly disagree	
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Comments

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Annexure 2

Matrices used in analysis part of the online system for python programming concepts.

The entered python code can be analyzed by the system with the support of ‘SonarQube’ which is the embedded third-party tool. When the result for the entered code is displaying, the following selected matrices are used as described below.

Lines of code

Lines of code are a software metric used to measure the size of a computer program. This is measured by counting the number of lines in the text of the program's source code. This metric is generally used to evaluate a software program or codebase according to its size. And this matrix is used to measure the complexity of a code.

Code smell

Code smell is any characteristic in the source code of a program that possibly indicates a deeper problem. Code smell refers to any symptom in the source code of a program that possibly indicates a deeper problem. It is a hint that something has gone wrong somewhere in the code. User can use the smell to track down the problem in the code. It will help user to track down and make corrections. It is a maintainability-related issue in the python code.

Duplicated lines

Duplicated line density is the number of duplicated blocks of lines of a python code.

Reliability rating

There are three metrics allow a user to enforce a given Rating of Reliability, Security and Maintainability on new code. Reliability rating describes different levels such as

- A = 0 Bug
- B = at least 1 Minor Bug
- C = at least 1 Major Bug
- D = at least 1 Critical Bug
- E = at least 1 Blocker Bug

Security rating

Security rating describes three different types of rules: Reliability (bug), Vulnerability (security), and Maintainability (code smell) rules.

Security rating explains different levels such as

A = 0 Vulnerability

B = at least 1 Minor Vulnerability

C = at least 1 Major Vulnerability

D = at least 1 Critical Vulnerability

E = at least 1 Blocker Vulnerability