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ITE-2004- SOFTWARE TESTING

SCHOOL MANAGEMENT SYSTEM

By

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Under the guidance of

Prof. Charanya R

Information Technology

Winter Semester 2021-2022

Declaration by the Candidate

We hereby declare that the project report entitled "**SCHOOL MANAGEMENT SYSTEM**" submitted by us to Vellore Institute of Technology University, Vellore in partial fulfillment of the requirement for the award of the course **Software Testing (ITE2004)** is a record of bonafide project work carried out by us under the guidance of **Dr. Charanya R.** We further declare that the work reported in this project has not been submitted and will not be submitted, either in part or in full, for the award of any other course.

Place : Vellore

Date : 26-04-2022 **Signature**

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Abstract

School Management System (SMS) is a web enabled application developed onJs Framework and powerful MongoDB database backend. To implement E- School, schools do not require expensive hardware and software, all schools need is internet connection and desktops. Our system works as a centralized database and application that schools can easily access the system from anywhere based on the login credentials. This is a platform independent system that virtually any user can access from anywhere through a standard internet accessible system. We'll test the system of school management with the automation testing tool katalon studio to test the functional requirements.

Keywords :

Study from home (SFH), administrators, teacher, students, Selenium, Jest, Appium,Katalon studio.

Introduction

1.1 Background :

The existence of the COVID-19 virus that spreads almost all over the world causes all activities to be carried out online to avoid a more massive spread of the virus. One of the steps implemented by the Government of India to overcome this problem is the implementation of Work from Home (WFH) and Study from Home (SFH) . This causes all schools at various levels of education to carry out the online learning process . With this policy, students can still participate in learning activities every day, but online at their respective homes.

Here we require a website so that we can cover all the needs of teachers and students at one time . Students can get the monthly marks obtained in various
assessments and also can request permission in the case not to go to school andthat teacher who can put signs and writes reports on each student activity and duties . Admin of the website can be the director of the school that is watchingall the students and teachers in terms of attendance and can monitor all complaints and reports and so in a short period of time. Hence we can say that this site facilitates all administrative tasks within and outside the school with ease.

Scope of the project :

This site will help students, teachers and administrators in following ways :

Administrators:

School Management System helps administrators get the most accurate information to make more effective decisions. Teachers and administrators gain time saving administrative tools, parents gain immediate access to their children's grades and students can track their own progress. School Management System equipped features makes it possible to generate schedules and reports in minutes and to retrieve attendance records, grade checks, report cards, transcripts, and form letters in just a few clicks.

Teachers:

School Management Systems helps Teachers to complete grade book, track students attendance, input class notes, create lesson plans and detailed reports. Communicate with other staff members, students, and parents all via e-mail.

Students:

School Management Systems helps Students to access assignments and tests. View attendance records, grades, report cards, and progress reports all online. Students also can communicate through mail and forums with teachers and students online.

Problem Statement :

School administrators today face a variety of issues on a daily basis, including school governance, dealing with parents, service education, and providing support to overworked teachers. It's always a good challenge for school administration to manage a school while also bringing departments and campuses together to achieve the mission; however, it's simple to achieve their goals by transforming schools with high-tech automation tools to support academic and administrative processes. To improve operational efficiency and effectively administer the institution, there is a rising need to modernise education with cloud, mobile, and digital technologies in order to meet schools' everyday requirements.

Every school administrator's very survival is dependent on the most crucial issue of vast amounts of paperwork and manual processes, which make it difficult for them to keep track of attendance, fees, admissions, transportation, and other data. Among the difficulties or obligations that school administrators encounter are:

10 most common issues at school management system are:

- Paper-based processes
- Online Registration
- Admission & Enrollment
- Course Management
- Teacher Evaluation
- Communication & Collaboration
- Classroom Management Strategy
- Student Monitoring
- Revenue Management
- Forecasting the academic achievement

LITERATURE REVIEW

1.) Analytical Study and Implementation of Web PerformanceTesting Tools

Divya Saharan, Yogesh Kumar, Dr. Rahul

RishiPublication Year: 2018

In this paper investigation correlation of performances of the testing tools of web application i.e. **Apache JMeter, NeoLoad, LoadUI and Loadster** is done based on various parameters. Performance parameters results generated by these performance testing tools have been evaluated and assessed in terms of usability test parameters & performance parameters. **Apache JMeter** is used to stack test utilitarian conduct and measure execution. It can be utilized for execution test both on staticand dynamic assets. **NeoLoad** is utilized to gauge the execution of the web application**. LoadUI** is anopen source execution testing device utilized for stack testing. It is utilized to check the execution of web application. **Loadster** is a Load testing Tool which is utilized for test answers for sites, web application and web administrations.It is worked for genuine web applications and dealing with treats, client sessions, custom header and dynamic frame information.

As per the performance comparison analysis in the paper it came out that the Loadster and NeoLoad would be most appropriate. The normal throughput reaction in NeoLoad and LoadUI stack testing tools are better when contrasted with different instruments. From general outcomes, **NeoLoad** indicates better outcomes regarding throughput and ease of use parameters moreover.

2.) Toward a Multi-Criteria Framework for Selecting SoftwareTesting Tools

ASMA J. ABDULWARETH1 AND ASMA A. AL-SHARGABI

Publication Year: 12th November, 2021

This research aims at developing a comprehensive taxonomy for testing tools that cover a broad rangeof testing tools criteria. This research introduces a framework for selecting testing tools. The proposed framework includes a comprehensive taxonomy of testing tools, and a selection method for developers to use the taxonomy for selecting appropriate testing tools. For all scenarios, method can determine the appropriate testing tools with accurate rank with the help of AHP with TOPSIS as a hybrid multi-criteria selection method. The results were accurate and the method always chooses the best tool with high rank and ranks all tools accurately from the best tool to the worst. For an example scenario for testing Open Education System -

System	Testing Criteria	Scenario /test Case Parameter	Result	
			Expected Results	Actual Results
Open Education System UST	Agile, Oracle, Usability	Many tools, Few criteria, **Close weight values for the criteria**	TestTrack Zephyr Testrail TestPAD	**TestTrack=1** Zephyr=0.87 Testrail= 0.49 TestPAD= 0.49 Selenium=0 Asml=0 Test Complete=0 QT=0 Appuinm=0 Sauce labs=0 Coverity=0 Ranorex=0

3	TestTrack,, Zephyr, Testrail, TestPAD	**TestTrack=1 (the best)** Zephyr=0. 87 Testrail=0.49 TestPAD=0.49 Selenium=0 Asml=0 Test Complete=0 QT=0 Appuinm=0 Sauce labs=0 Coverity=0 Ranorex=0

As we can see TestTrack come out as the best testing tool for following testing criteria to test Open Education System. Using the proposed framework would help developers to choose the best testing tools for their software based on the criteria of both tools and the software.

3.) Serverless Testing: Tool Vendors' and Experts' Points of View

Valentina Lenarduzzi, Annibale

Panichella Publication Year: 22

December 2020

This article focuses on the testing and debugging of serverless- based applications. Considering the continuous evolution of cloud-based software systems, testability becomes an important factor, especially for integration and regression testing. Author defined test cases to cover the possible events and data values that each function receives from the outside. Similarly, it tests for possible values lambda functions may return. The author defined new and more appropriate test adequacy criteria for serverless application, new fault localization and crash-reproducing techniques for microservice applications, big data analytics for distributed logs and test case-generation tools specific for serverless applications and the interactions across lambda functions.

4.) Application of Learning Management System to Improve Teaching and Learning Activities in Vocational High Schools

Eka Larasati Amalia, Annisa Puspa Kirana, Vivin Ayu Lestari, Vivi Nur Wijayaningrum,Aisyatush Shofiah

Publication Year: 2021

COVID-19 virus pandemic has forced the teaching and learning process to be done online. One solution that can be used to overcome the problems of having a proper way of systematic education is the use of an E-Learning system. In this study, an E-Learning system was developed for vocational high schools with a number of features that can be used to support the learning process The usability

test results show that this E-Learning system can be applied to Vocational High Schools with a scoreof 90.8%, which means the system can be used to support the learning process during the pandemic. In this paper a web-based LMS developed by utilizing the Laravel Framework.

Based on the results of the tests that have been carried out, the LMS that has been developed in this study can function very well. All the features available to each user in the LMS can run according tothe needs of users in vocational high schools. This is evidenced by the average value of the usabilitytest results of 90.80%.

5.) Practices of Software Testing Techniques and Tools inBangladesh Software Industry

Trina Saha_, Rajesh Palit

Publication Year: 2021

In this paper, the author surveyed 10 leading software firms in Bangladesh software industry to assessthe current practices of software testing techniques and tools in the industry. The authore also rectifiedpresent barriers and challenges that impeding the industry from producing better products. Software industry used to maintain software quality using manual testing process, which is being replaced by automated testing tools.
It is also seen from the analysis the usage Selenium as automation software testing tool for testingweb application is much greater .

6.) A Critical Analysis of Software Testing Tools

Authors : F. Okezie, Odun-Ayo and S.

BoglePublication Year : 2019

Software testing plays an important role in the development of software as it guarantees that thesoftware been deployed to the market is free from effects and errors.

Automated testing is used over manual testing as it saves time and also minimize cost incurred in the organization during the testing phase. In this paper, I evaluated some automated testing tools which includes selenium, testcomplete, Ranorex, OpenScript, Janova, etc, highlighting their basic features and characteristics.

I think that in selecting any tool, the size of the project and the cost budgeted for testing should be considered, also the platform where that project would be used should reflect in the criteria for selecting a testing tool. From the result obtained in this study, I recommend TestComplete and Ranorex testing tools for testing across all platforms and when the project to be tested is large, since they are both licensed tools, the budget for testing should be put into consideration. Appium is

recommended for strictly mobile testing, while selenium for web testing with the advantage that it isopen source.

7.) A Comparative Analysis On Software Testing Tools AndStrategies

Authors : Pramod Mathew Jacob, Priyadarsini S, Renju Rachel Varghese, Sumisha Samuel,Prasanna Mani

Publication Year : 2020

Lots of software testing tools available in the market, out of which the most successful ones include Selenium, HPE Unified Functional Testing (UFT). Based on their functional features and their role intesting process , we classify various software testing tools .

My comparative analysis mainly evaluates two widely accepted software testing tools:
Selenium : Selenium is an open source, portable testing framework mainly focusing on web applications. Selenium has a recordplayback tool for authorizing tests without learning to develop testscripts.
HPE Unified Functional Testing (UFT) : UFT is widely used for enterprise quality assurance. It provides a GUI and features for keyword and scripting interfaces. It uses VBScript to write the testscripts. HP UFT is a single console for verifying the interface, database and service layers of a software or application.

Selenium and HPE UFT are widely used tools where the former is open-source and later is licensed. HPE UFT can be used for both webpage and desktop applications whereas Selenium restricted only for web applications. Though Selenium is freeware, we cannot chose it always, because of the need of an experienced test professional. HPE UFT is comparatively easier to use and develops test scripts in less time.

8.) Automated Software Testing Tools

Authors : Saja Khalid Alferidah, Shakeel Ahmed Publication Year :

2020

In this paper the author discussed various automated testing tools that can perform an automated testfor software but there are many challenges for designing and development of automated testing tools such as it needs high performance, it must be easy to learn and effective tool.

Functional Testing Tools

Functional testing is the type of test to validate if the website or web application correctly perform allthe required functions.

1) Selenium: Selenium is an automated functional testing tool. It uses simple scripts to run the testdirectly in the browser . It can run on different platforms. It allows the tester to edit, record anddebug tests . Selenium is an easy setup tool.

2) FitNesse: FitNesse an automated testing tool, wiki, and web server all rolled into one application. It is used for functional and acceptance testing. It allows the tester, programmer or customer to knowthat their software should do and provide an automatic comparision to what itdoes. FitNesse saves acopy for all pages and of every version.

Regression Testing Tools

An automated regression test is similar to an automated functional test that validates the functionalityof the system and checks if the new added functionality of the system does not make an error or bugsto the system.

1) Selenium can be a tool for regression testing.

2) Quick Test Professional (QTP): QTP it provided by HP/Mercury Interactive. It is an automated regression testing tool. It uses visual basic (VB) language. QTP can be used in both manual testingand automated testing .

3) Sahi: Sahi also is an automated testing tool. It uses a web application. It was developed in Java andJavascript and hosted on SoundForge. It applies to record and plays back the scripts.

9.) A Study and Analysis on Software Testing Tools

Authors : R.Akiladevi, P.Vidhupriya,

V.SudhaPublication Year : 2018

This paper discusses about the various software testing tools which is focused on Test Management, Functionality and load. It portrays the survey of these three different automated tools with their prosandcons.

Test Management Tools: They are used to maintain and plan manual testing, run or gather executiondata from automated tests, manage multiple environments and to enter information about found defects.

Functional Testing Tools: Functional testing is a type of testing which verifies that each function of the software application operates in conformance with the requirement specification.

Load Testing Tools: Load testing is the process of putting demand on a software system or computing device and measuring its response. Load testing is performed to determine a system's behaviour underboth normal and anticipated peak load conditions.

Depending on the various scripting language used and execution environment a suitable tool can be chosen. We use management testing tools for checking functionality and interfaces it has a universal management and reporting framework and used for bug breaking facilities. When we have to automate Web browsers across many platforms we use functional testing tools , it is a browser independent recorder that records interactions with websites. Whereas Load Testing Tools such as Jmeter is a Java application designed to load test functional behavior and measure performance.

10.) Classification of Software Testing Tools Based on theSoftware Testing Methods

Authors : Khaled M. Mustafa, Rafa E. Al-Qutaish, Mohammad I.

MuhairatPublication Year : 2009

In this paper, we have classified and distributed 135 testing tools over eight types of software products. Furthermore, we have distributed the testing tools over the types of testing for three types of software products (web application, application software, network protocol).

Based on our study and analysis of the testing tool, we have concluded the following comments andsuggestions:

1. The testing tools for the embedded and system applications are very limited.

2. For the web application software products, the testing tools for the unit, acceptance, and opensource testing methods are restricted.

3. For the application software products, the testing tools for the security and system testing methodsare restricted.

4. The testing tools for functional testing in both the web applications and application software product are very common.

5. For the network software products (TCP protocol), there is no any testing tool for the system,acceptance, unit, functional, and regression testing methods.

Comparative Study of Various Testing Tools:

Tools	Comparison
1. Apache JMeter	The Apache JMeter™ application is open source software which is a Java application designed to load test functional behavior and measure performance. Apache JMeter is used to stack test utilitarian conduct and measure execution. It can be utilized for execution test both on static and dynamic assets.
2. NeoLoad	NeoLoad is basically an automated performance testing platform which is utilized to gauge the execution of the web application. Its used to determine performance under load, number of the simultaneous users, response time etc.
3. LoadUI	LoadUI is an open source execution testing device utilized for stack testing. It is utilized to check the execution of web application.
4. Loadster	It is a Load testing Tool which is utilized for test answers for sites, web application and web administrations.It is worked for genuine web applications and dealing with treats, client sessions, custom header anddynamic frame information.
5. Selenium	Selenium is a widely used open source, portable testing framework mainly focusing on web applications. Selenium has a recordplayback tool for authorizing tests without learning to develop test scripts. It provides a particular interface which let you to write test scripts in various languages like Java, Ruby PHP, NodeJS, Python, and C#, among others.
6. HPE Unified Functional Testing(UFT)	UFT is widely used for enterprise quality assurance. It provides a GUI and features for keyword and scripting interfaces. It uses VBScript to write the test scripts. HP UFT is a single console for verifying the interface, database and service layers of a software or application.
7. FitNesse	FitNesse an automated testing tool, wiki, and web server all rolled into one application. It is used for functional and acceptance testing. It allows the tester, programmer or customer to know that their software should do and provide an automatic comparision to what it does. FitNesse saves a copy for all pages and of every version.

8. Sahi	Sahi also is an automated testing tool. It uses a web application. It was developed in Java and Javascript and hosted on SoundForge. It applies torecord and plays back the scripts.
9. Jest	It is a universal testing platform, with the ability to adapt to any JavaScript library or framework. It is primarily designed for React (which is also built by Facebook) based apps but could be used to write automation scenarios for any Javascript-based codebases.
10. Appium	Appium is an open-source automation mobile testing tool, which is usedto test the application. It is developed and supported by Sauce Labs to automate native and hybrid mobile apps. It is a cross-platform mobile automation tool, which means that it allows the same test to be run on multiple platforms. Multiple devices can be easily tested by Appium in parallel.
11.Ranorex:	Ranorex is a powerful tool for test automation. It is a GUI test automation framework used for the testing of web-based, desktop, and mobile applications. Ranorex does not have its own scripting language to automate application. It supports many technologies like Silverlight, .NET, Winforms, Java, SAP, WPF, HTML5, Flash, Flex, Windows Apps (Native/Hybrid), and iOS, Android.
12.OpenScript	OpenScript is an updated scripting platform for creating automated extensible test scripts in Java. Combining an intuitive graphical interface with the robust Java language, OpenScript serves needs ranging fromnovice testers to advanced QA automation experts.
13.Janova	Janova is a web-based, automated software testing tool that turns plain English business rules into tests themselves. Janova works behind the scenes through a cloud-based system of workers, automatically scaling and delegating processing power to ensure the fastest possible results fortests.
14.Protractor	Protractor is an end-to-end test framework for Angular and AngularJS applications. Protractor runs tests against application running in a realbrowser, interacting with it as a user would.

Survey Analysis of various Testing Tool in Industry:

After studying various journals regarding software testing tools it is visible that Selenium is the most used software testing tool for web application. As it has many advantages over the other tools like it supports various operating system, programming language, browser, parallel test execution and many more. We have come across survey analysis of usage of automation tools for functional testing for web application in the software industries and found out the following results.

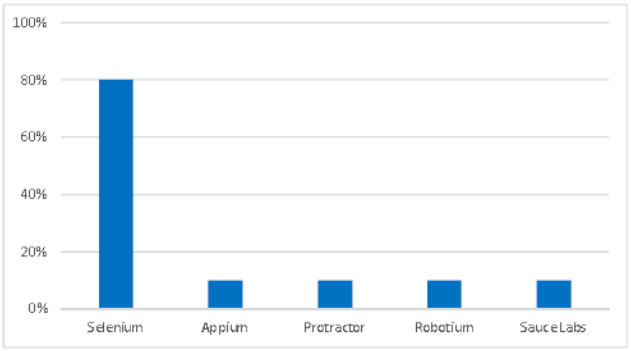


Fig. 9. Usage of automation tools for functional testing of web application.

Development phase :

We have developed school management website using the following languages:

- Html and CSS
- Node JS
- Javascript
- Express JS
- MongoDB
- JQuery

Link of the hosted Website :

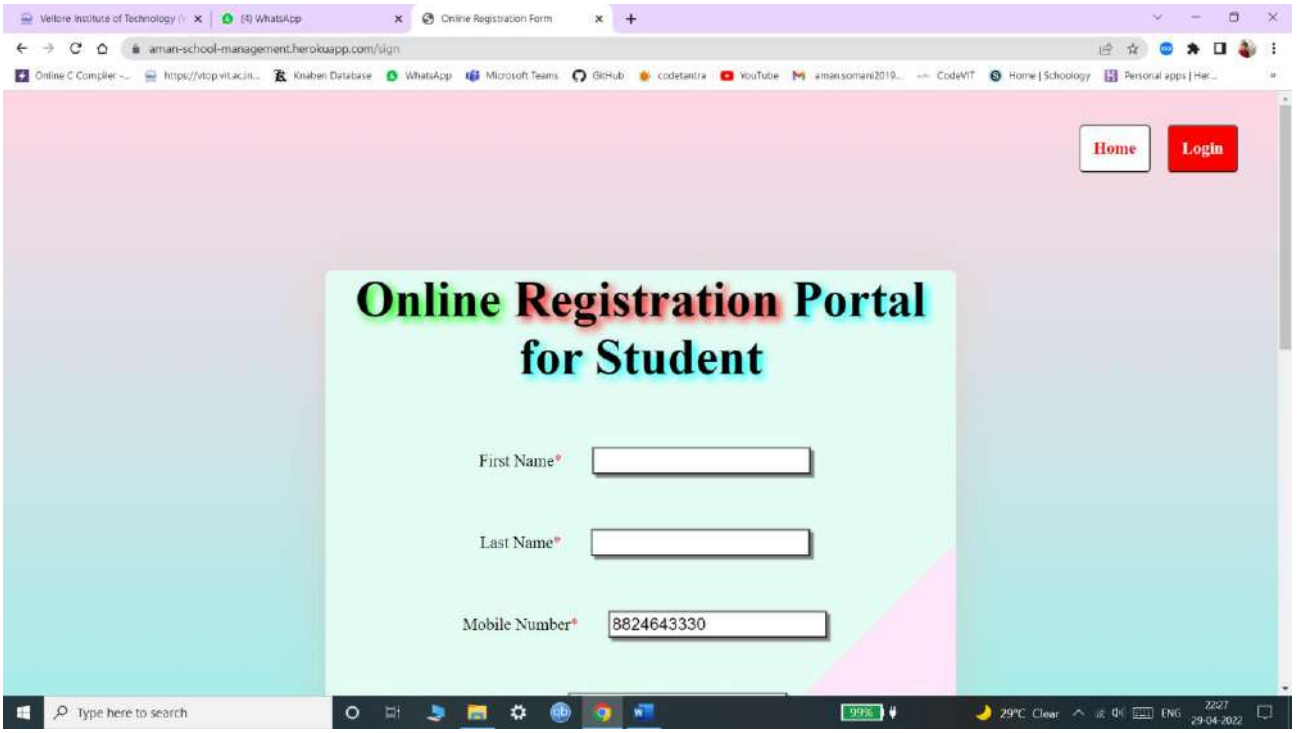
https://aman-school-management.herokuapp.com/

Complete code can be found at :

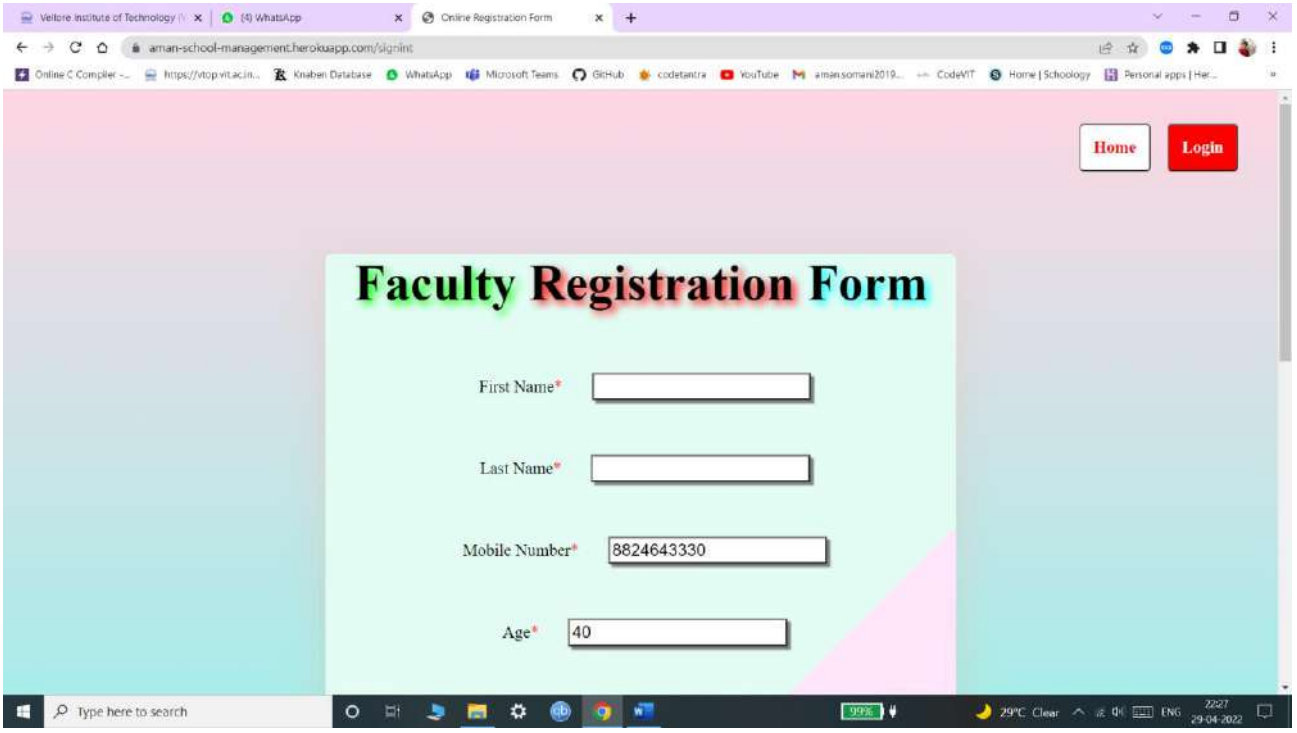
https://github.com/Aman235820/School-Management-Software

USER INTERFACE OF THE WEBSITE

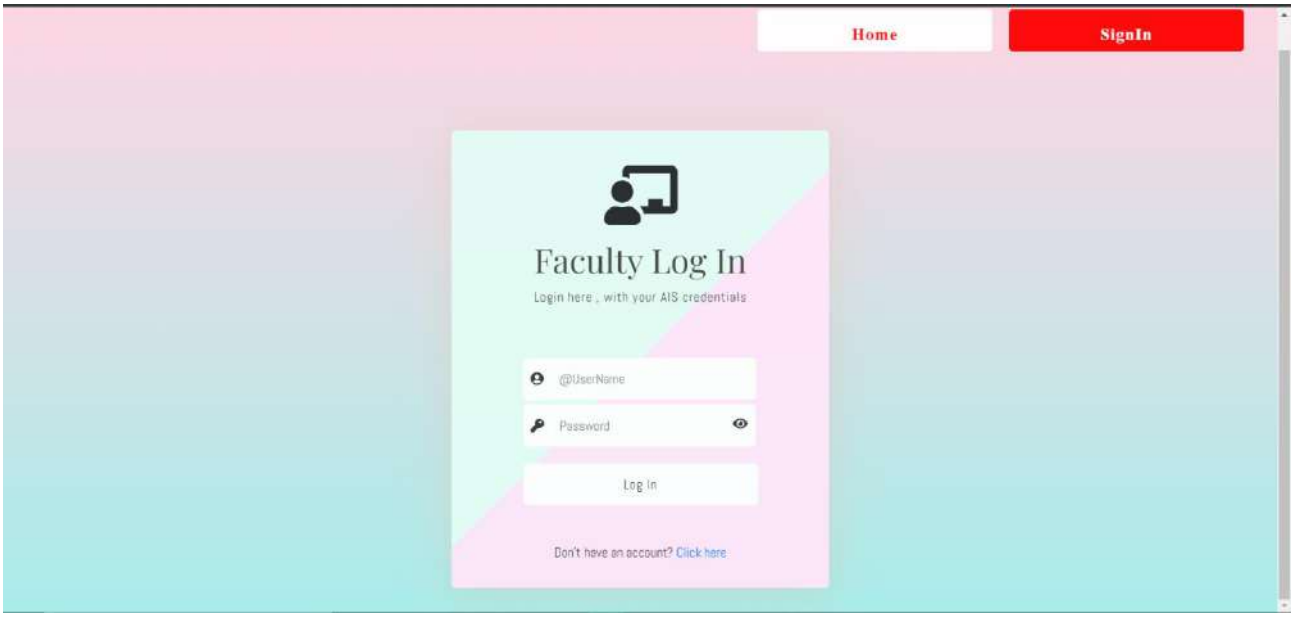
1. Student Registration Module :



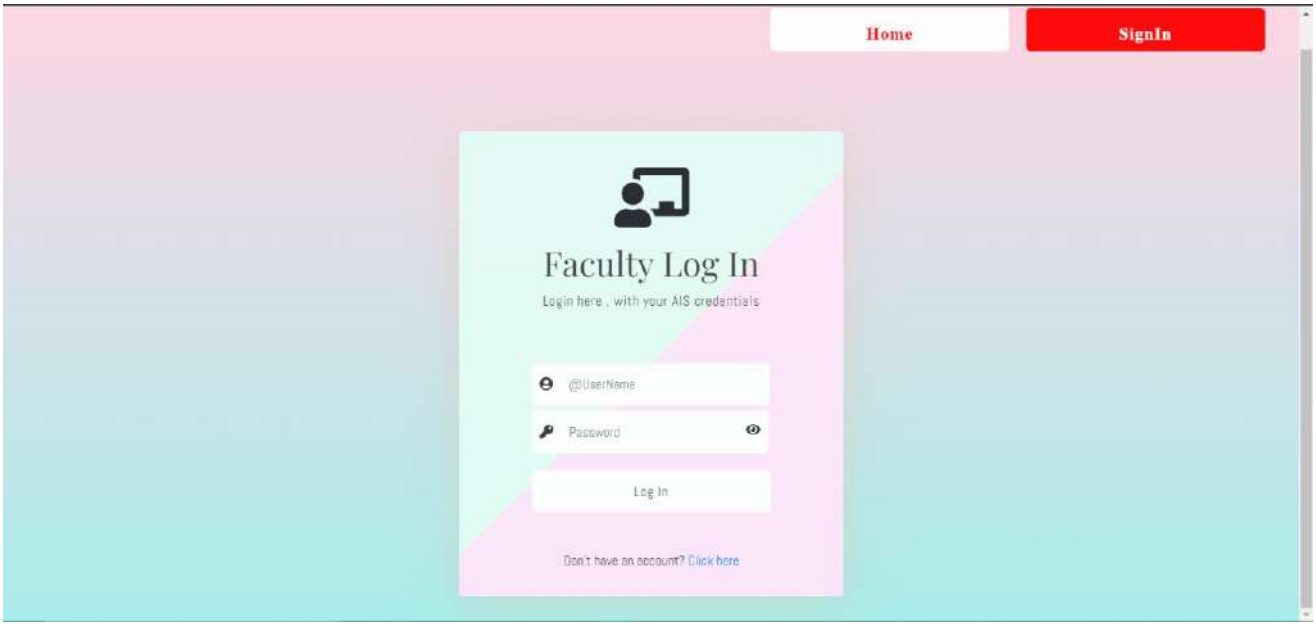
2. Faculty Registration Module:



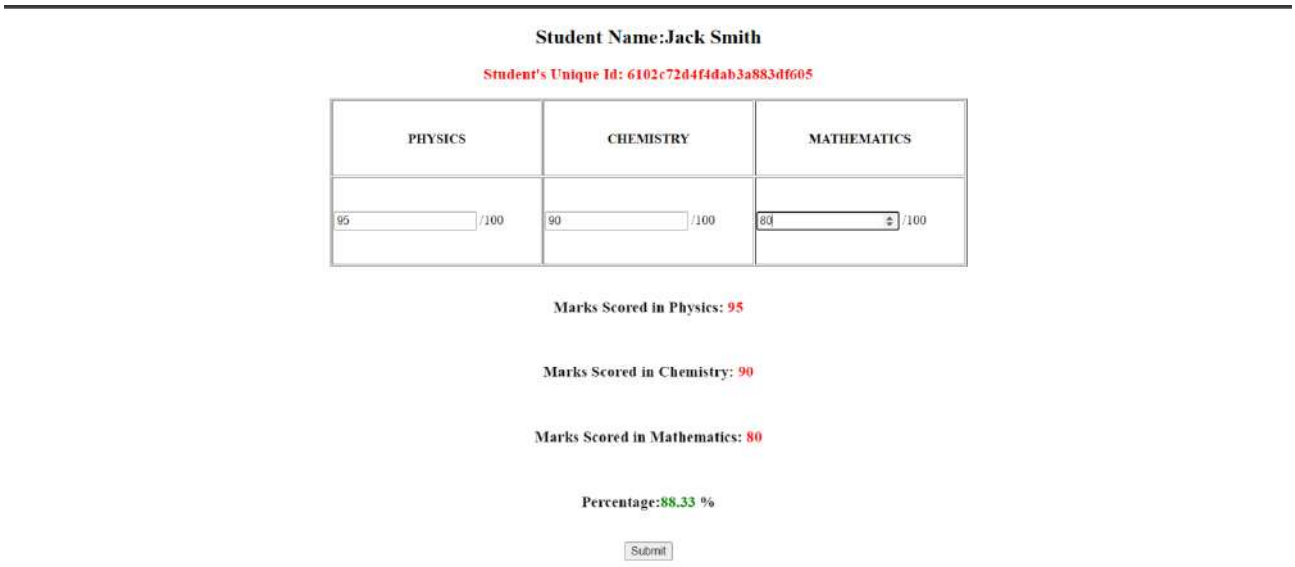
3. Student Login Module:



4. Faculty Login Module:



5. Marks Module:



6.Attendance Module:

Testing Phase

After exploring several automation testing tool we have decided to go for Katalon Studio Testing tool to test our software.

Possible Test cases for Student Registration Module:

List of Tables :

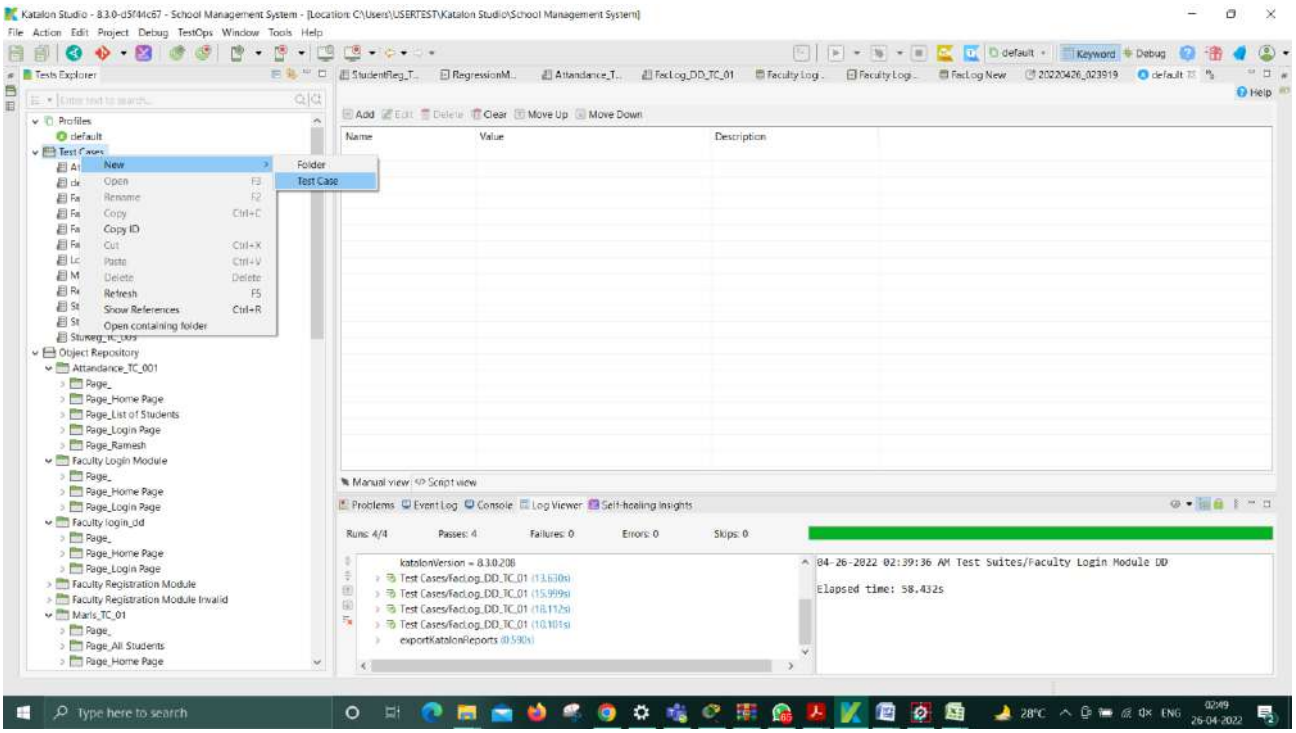
Test case id	Test Title	Steps to be followed	Test Data	Expected Result	Post Condition	Actu al Result	Status
T01	Registration using name, mobile number,age, email testing	1.Enter name 2.Enter mobile no 3.Enter age 4. Enter email 5. Register	Name: Rohan Mobile-9756258985 Age: 21 Email: rohan01@gmail.com	Valid for registration	Registration completed	Valid	Pass
T02	Registration using name, mobile number,age, email testing	1.Enter name 2.Enter mobile no 3.Enter age 4. Enter email 5. Register	Name: 13568 Mobile-9756258985 Age: 21 Email: ghub01@outlook.com	Invalid for registration	Name should be alphabet only.	Invalid	Fail
T03	Registration using name, mobile number,age, email testing	1.Enter name 2.Enter mobile no 3.Enter age 4. Enter email 5. Register	Name: Rohan Mobile-9543 Age: 35 Email: abc22@gmail.com	Invalid for registration	Mobile number should contain 10 character	Invalid	Fail
T04	Registration using name, mobile number,age, email testing	1.Enter name 2.Enter mobile no 3.Enter age 4. Enter email 5. Register	Name: Abhisekh Mobile-97528956478 Age: -20 Email: rohan01@gmail.com	Invalid for registration	Age can not be negative	Invalid	Fail

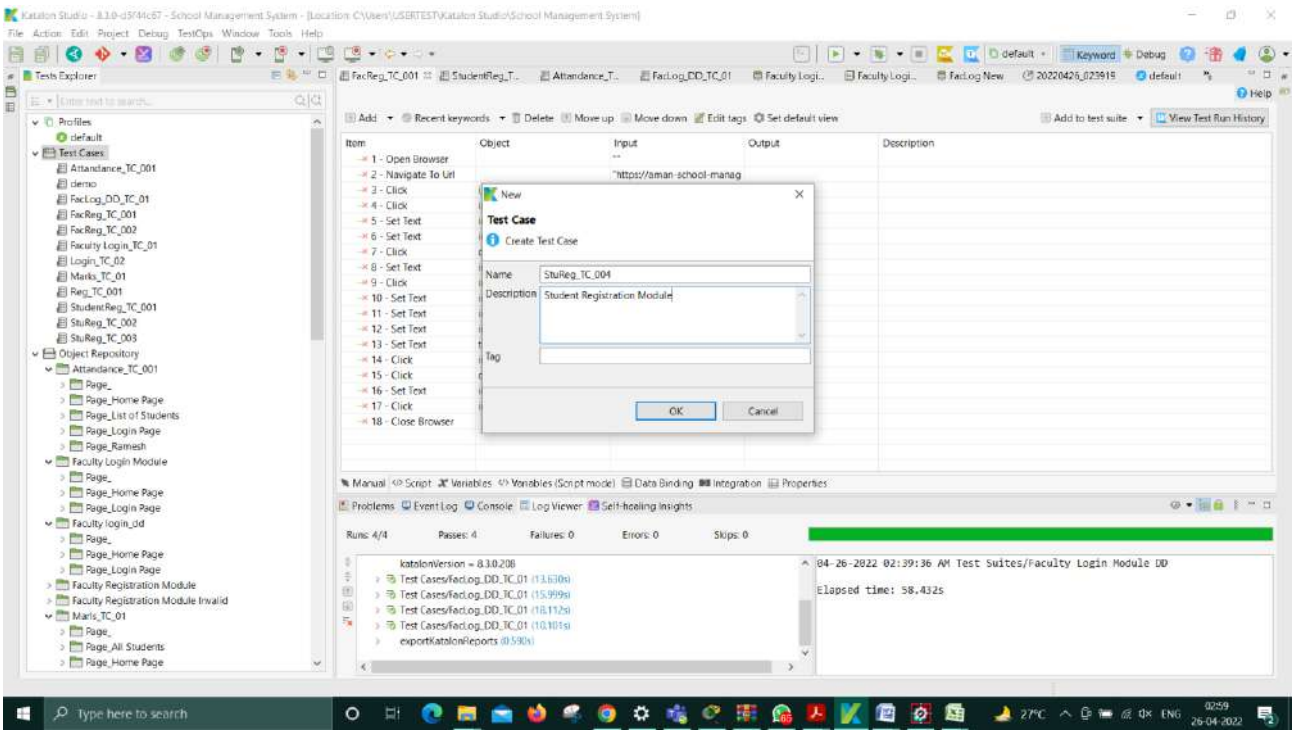
T05	Registration using name, mobile number,age, email testing	1.Enter name 2.Enter mobile no 3.Enter age 4. Enter email 5. Register	Name: Subham Mobile-9756258985 Age: 25 Email: #&@**outlookcom	Invalid for registration	Email should be valid	Invalid	Fail
T06	Registration using name, mobile number,age, email testing	1.Enter name 2.Enter mobile no 3.Enter age 4. Enter email 5. Register	Name: Mobile-9756258985 Age: 25 Email: rohan01@gmail.com	Invalid for registration	Enter name	Invalid	Fail
T07	Registration using name, mobile number,age, email testing	1.Enter name 2.Enter mobile no 3.Enter age 4. Enter email 5. Register	Name: Aman Mobile-9756258985 Age: 20 Email: aman56@gmail.com	Valid for registration	Registration completed	Valid	Pass
T08	Registration using name, mobile number,age, email testing	1.Enter name 2.Enter mobile no 3.Enter age 4. Enter email 5. Register	Name: Deepak Mobile-9956258985 Age: 154 Email: xyz45@gmail.com	Invalid for registration	Age should be less than 100	Valid	Pass
T03	Registration using name, mobile number,age, email testing	1.Enter name 2.Enter mobile no 3.Enter age 4. Enter email 5. Register	Name: Madhur Mobile-9756258985 Age: 18 Email: madhur02@outlook.com	Valid for registration	Registration completed	Valid	Pass
T10	Registration using name, mobile number,age,	1.Enter name 2.Enter mobile no 3.Enter age 4. Enter email	Name: Harsh Mobile-0123456789 Age :26 Email:	Invalid for registration	Registration incomplete, Enter email	Invalid	Fail

Implementation:

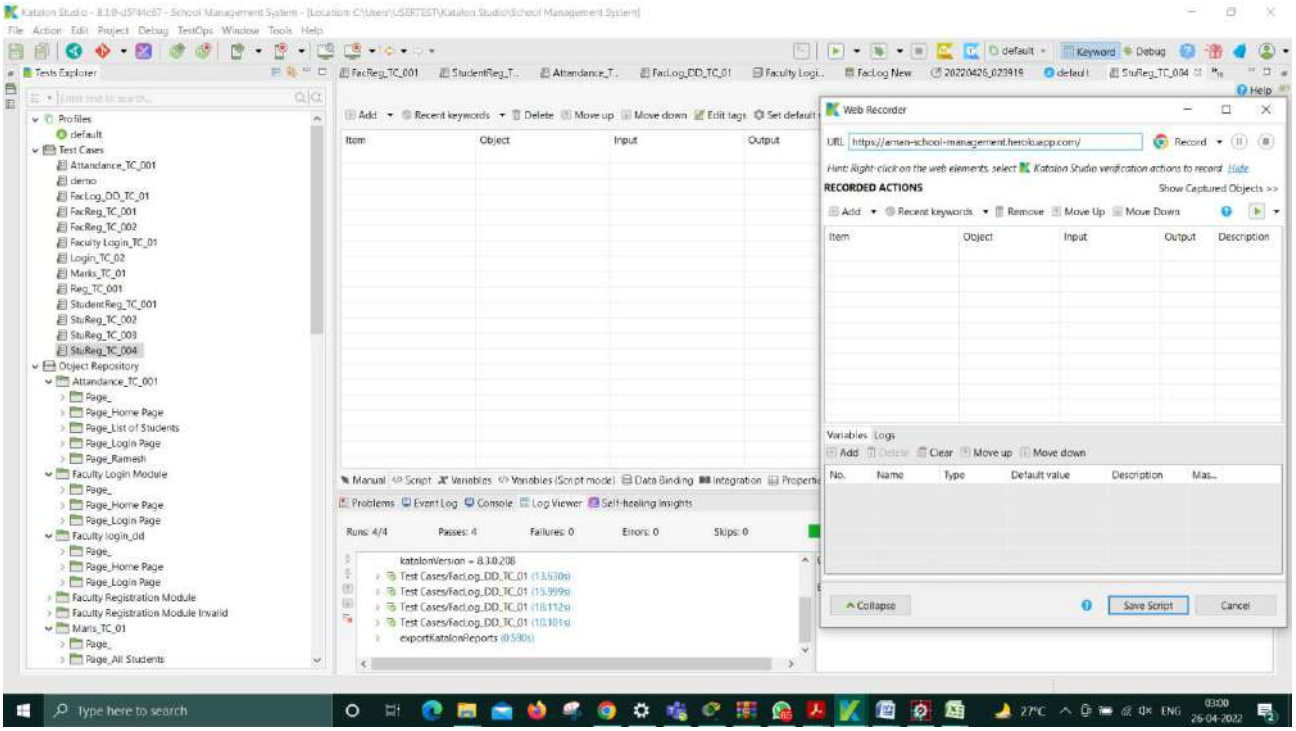
Designing Test Cases for the modules:

Creation of a new test case to test the Student Registration module of the School Management website.

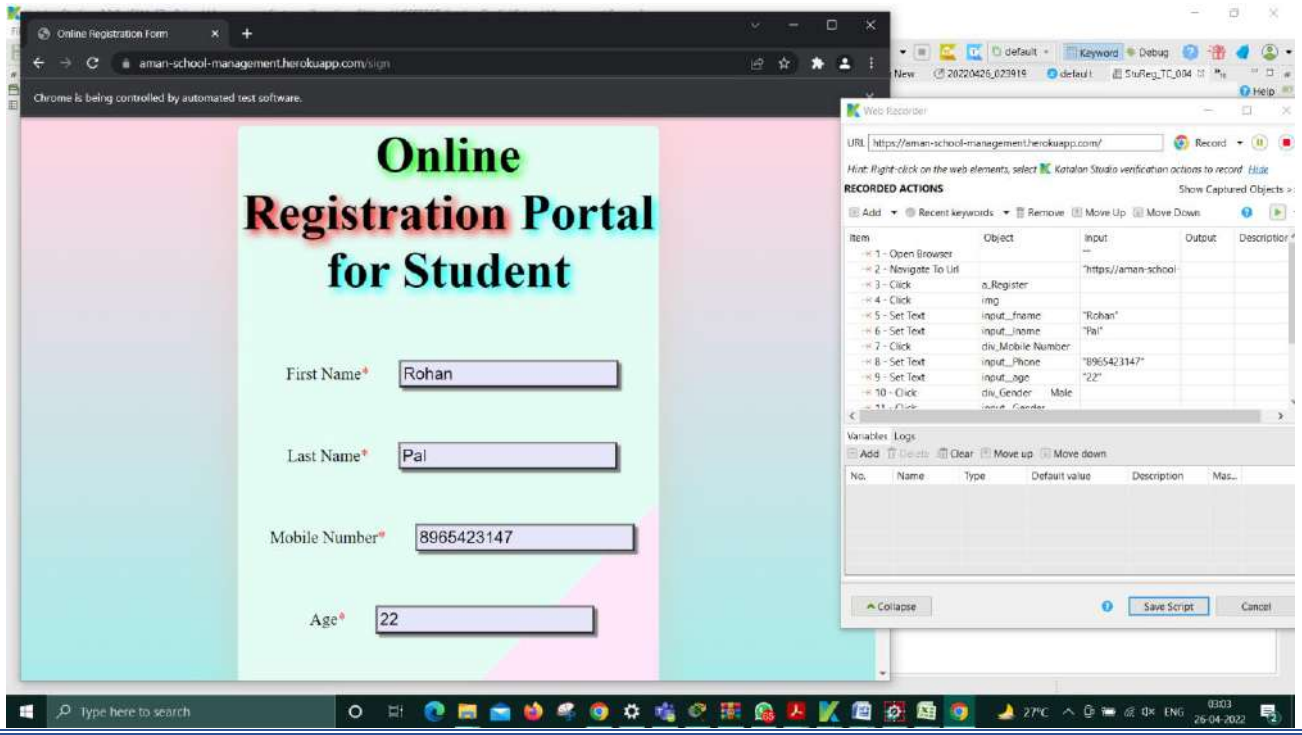


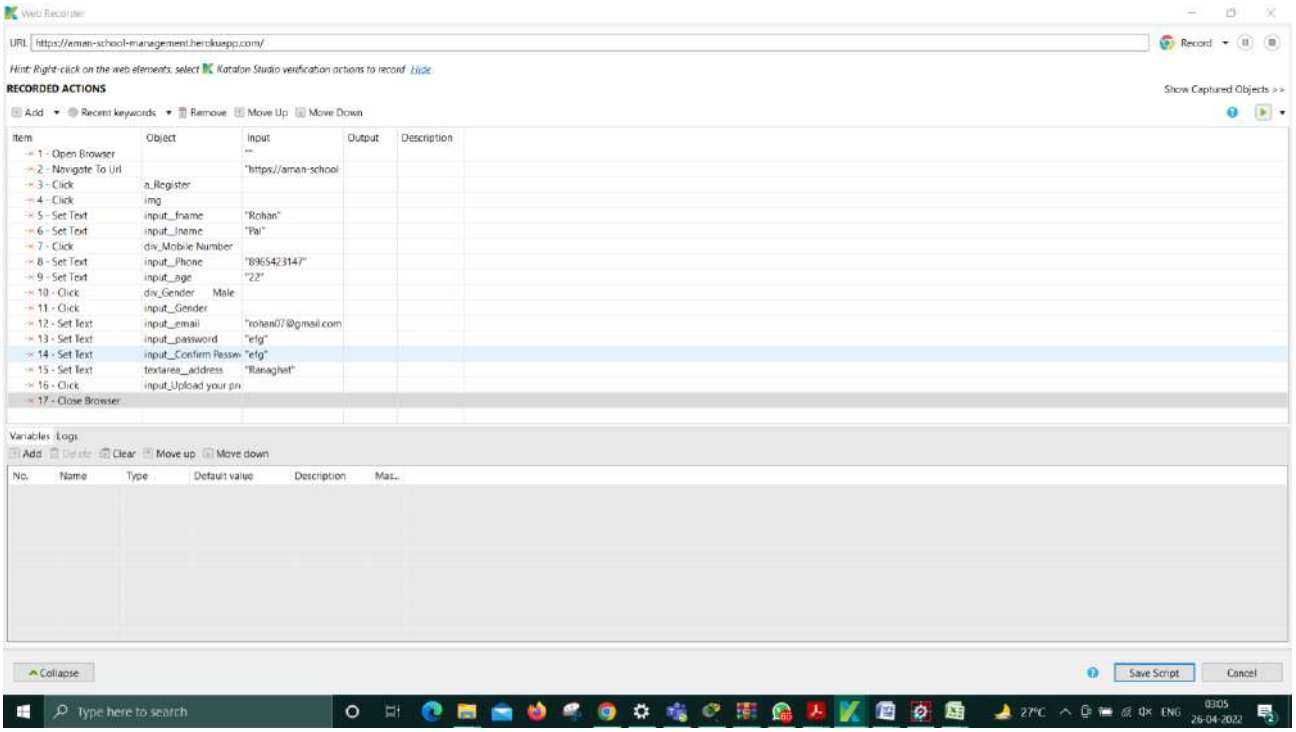


Starting the Web test recording by mentioning the website link:

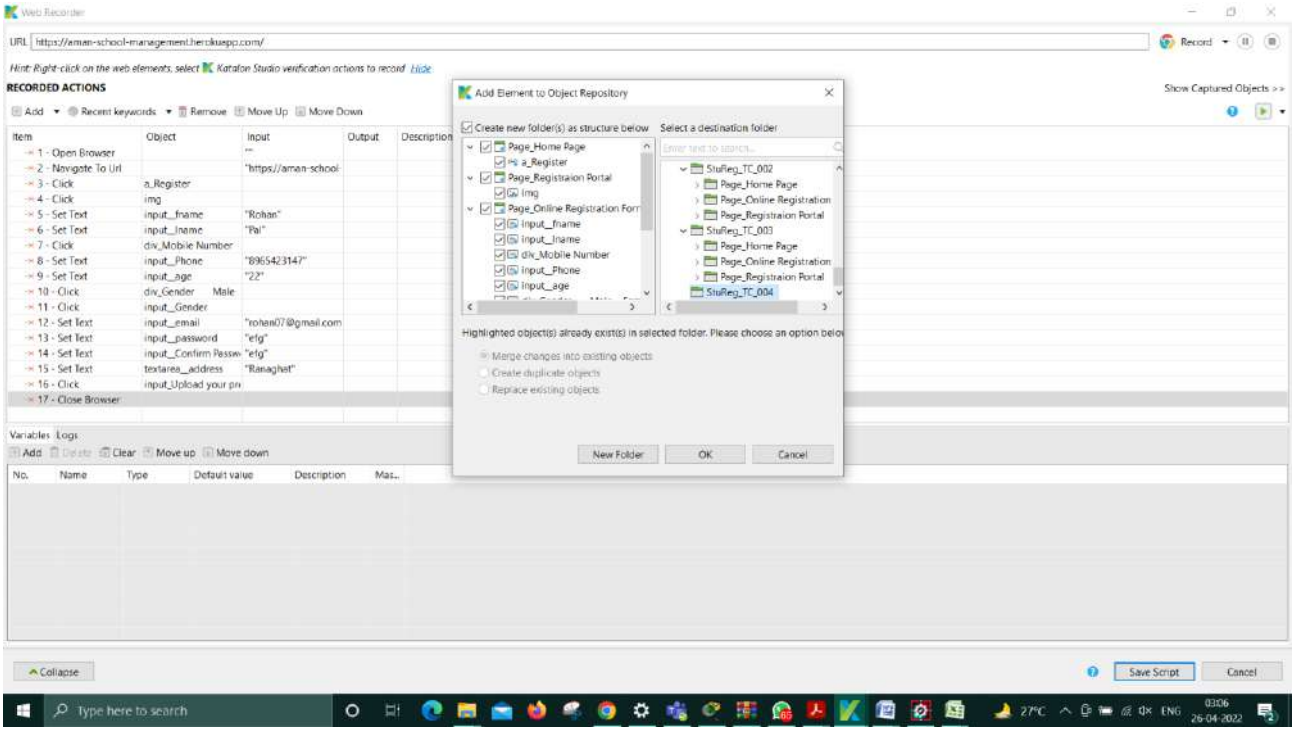


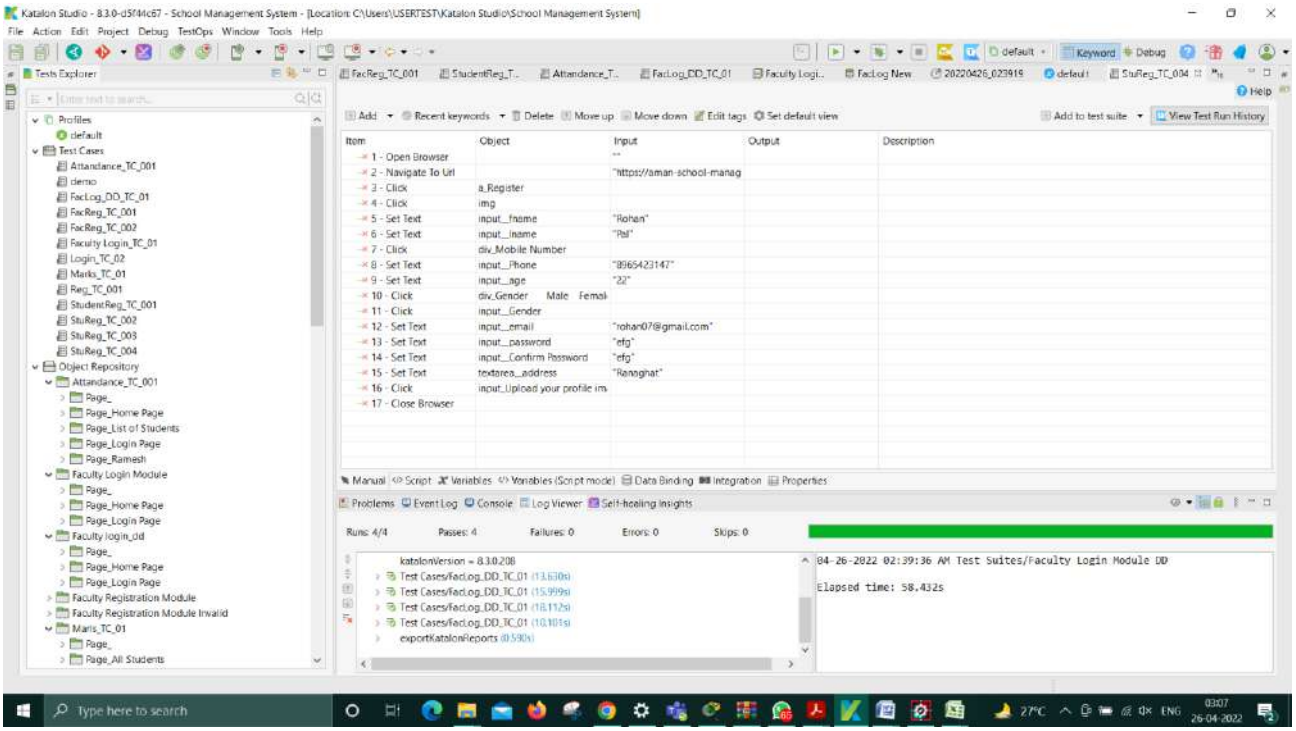
Recording test cases for the Student Registration module :-



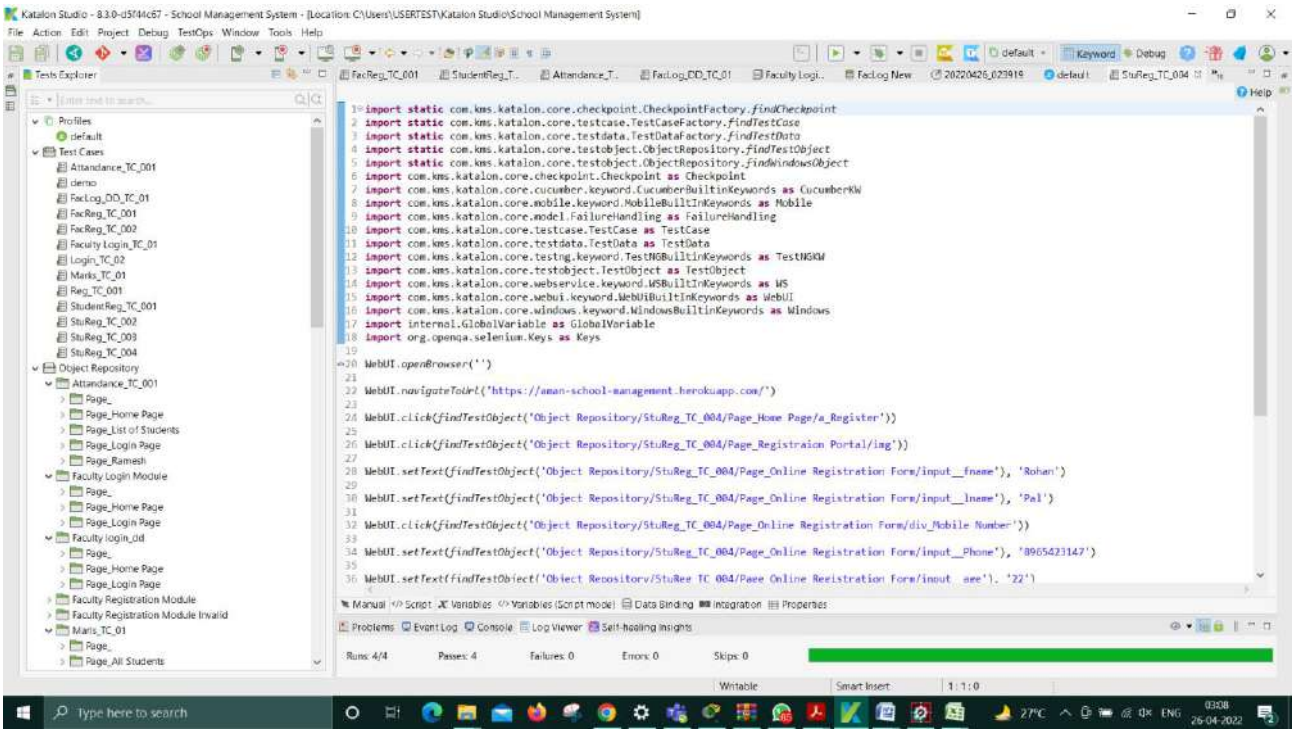


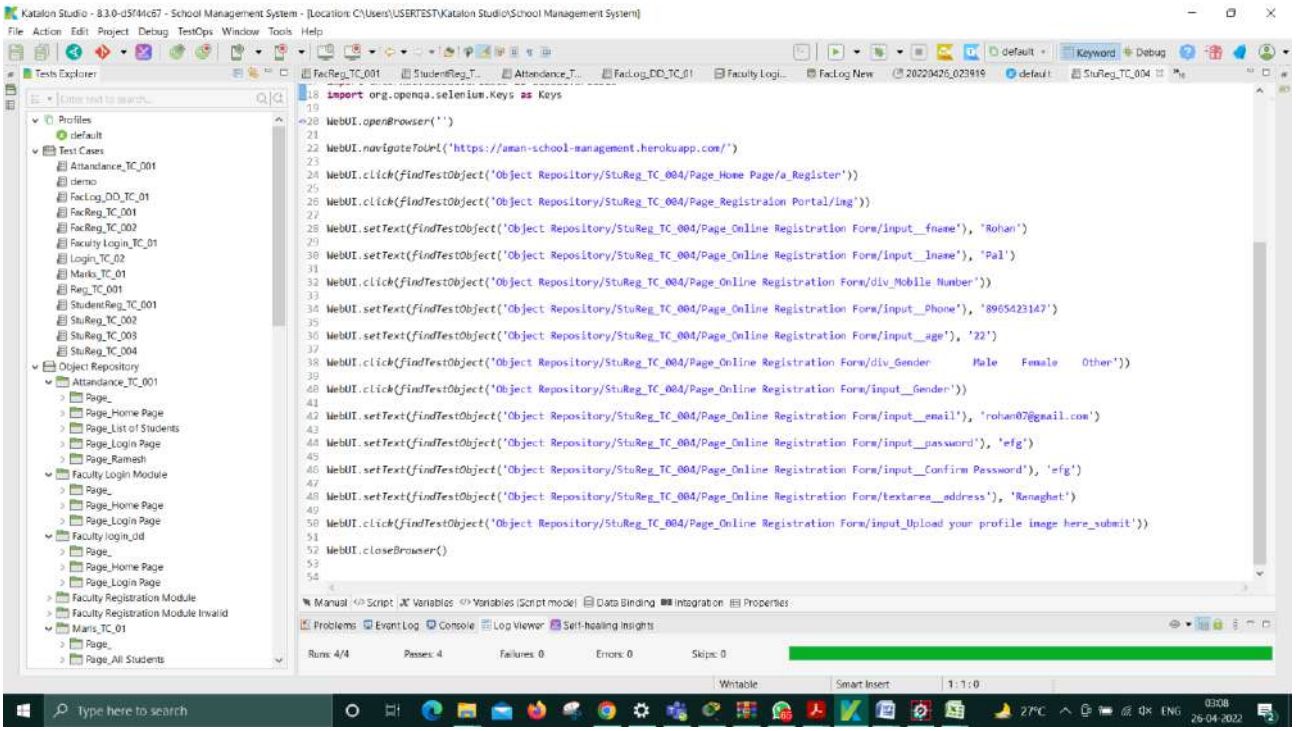
Upon clicking Save Scripts and stopping the recording all the actions performed while test recording are recorded along with the entered values and the objects of the webpage :-



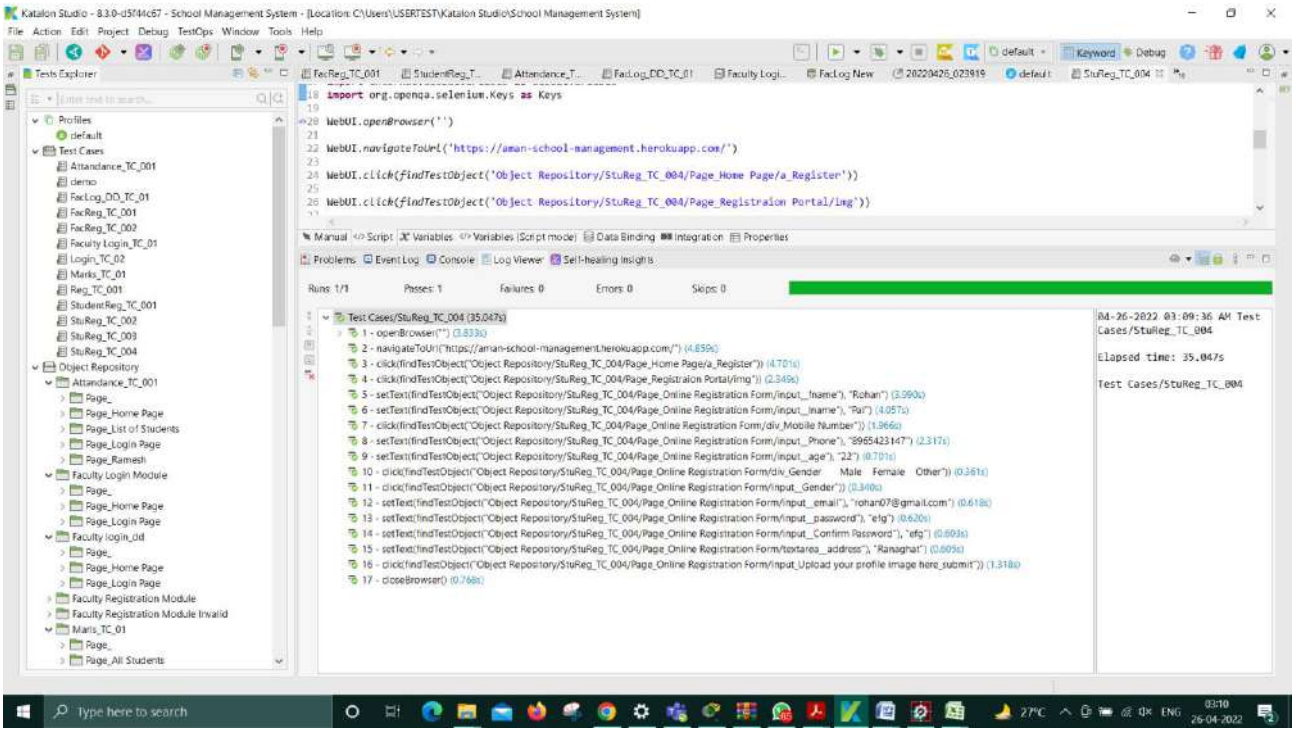


Screenshot of the generated test scripts :-



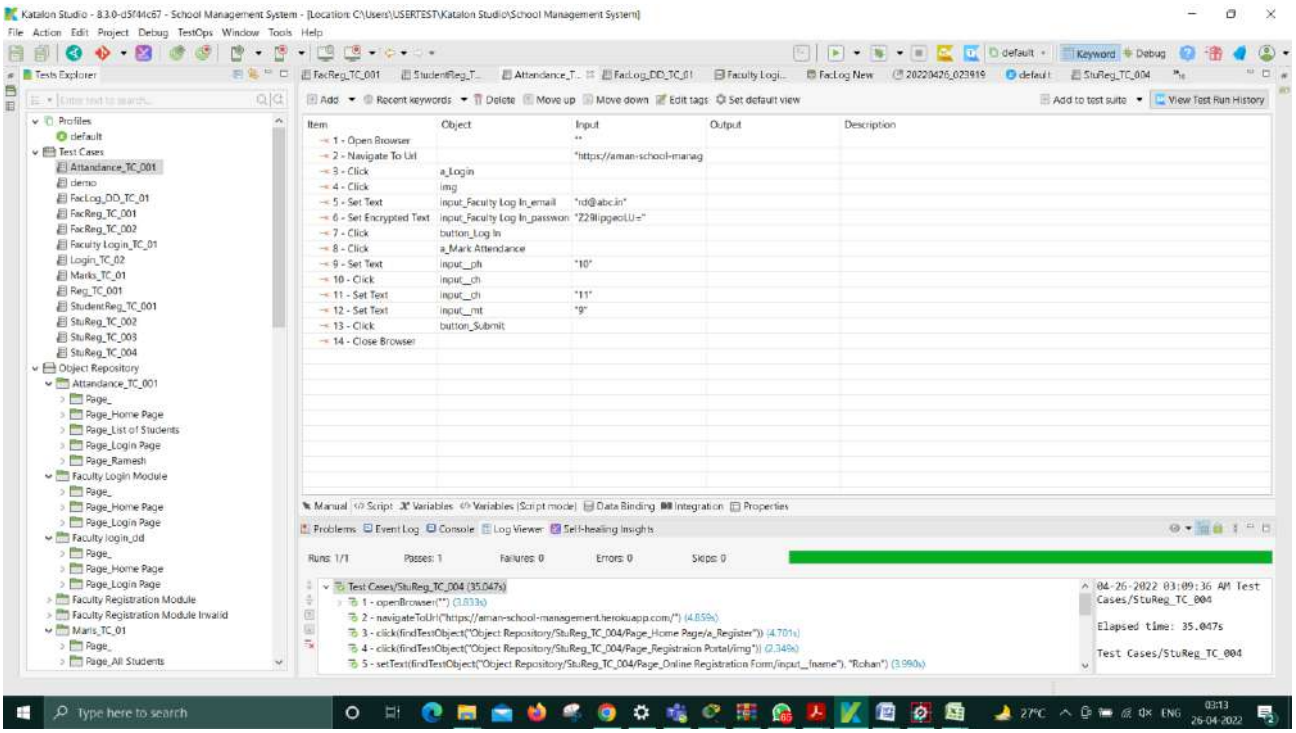


Testing of the recorded test cases (all passed) :-

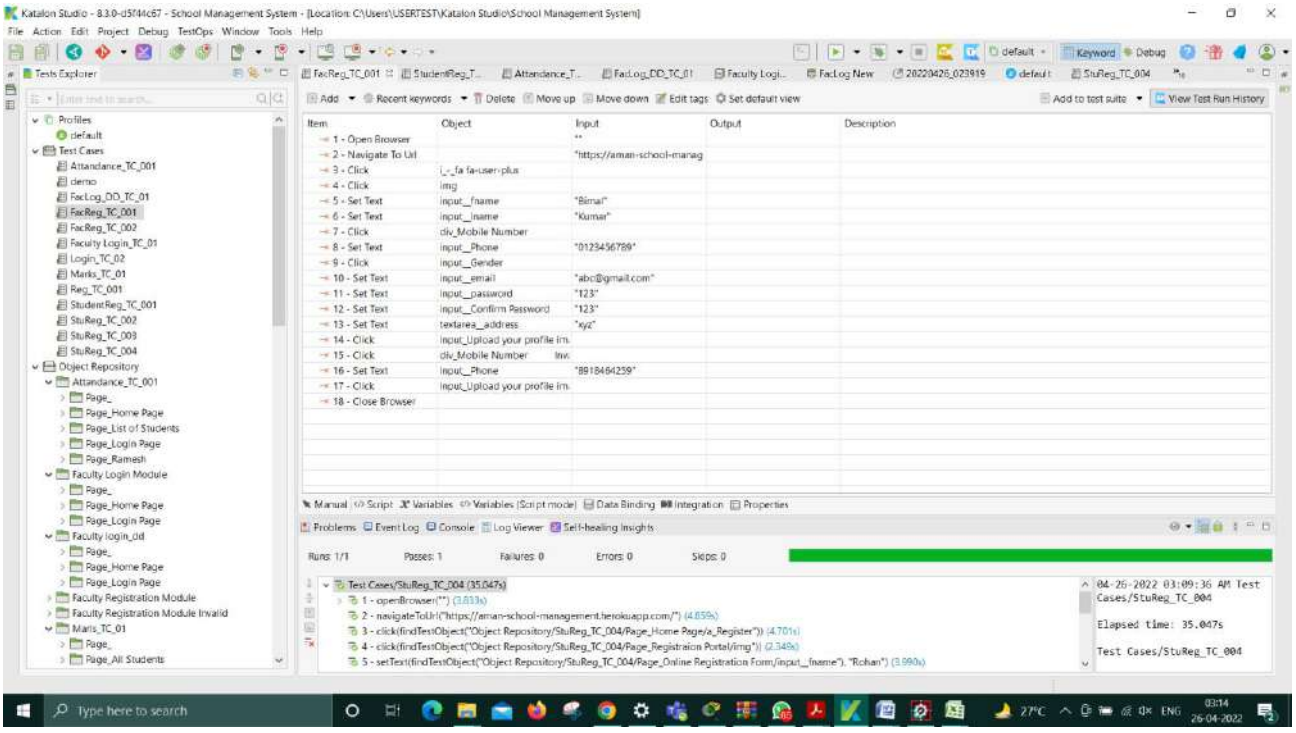


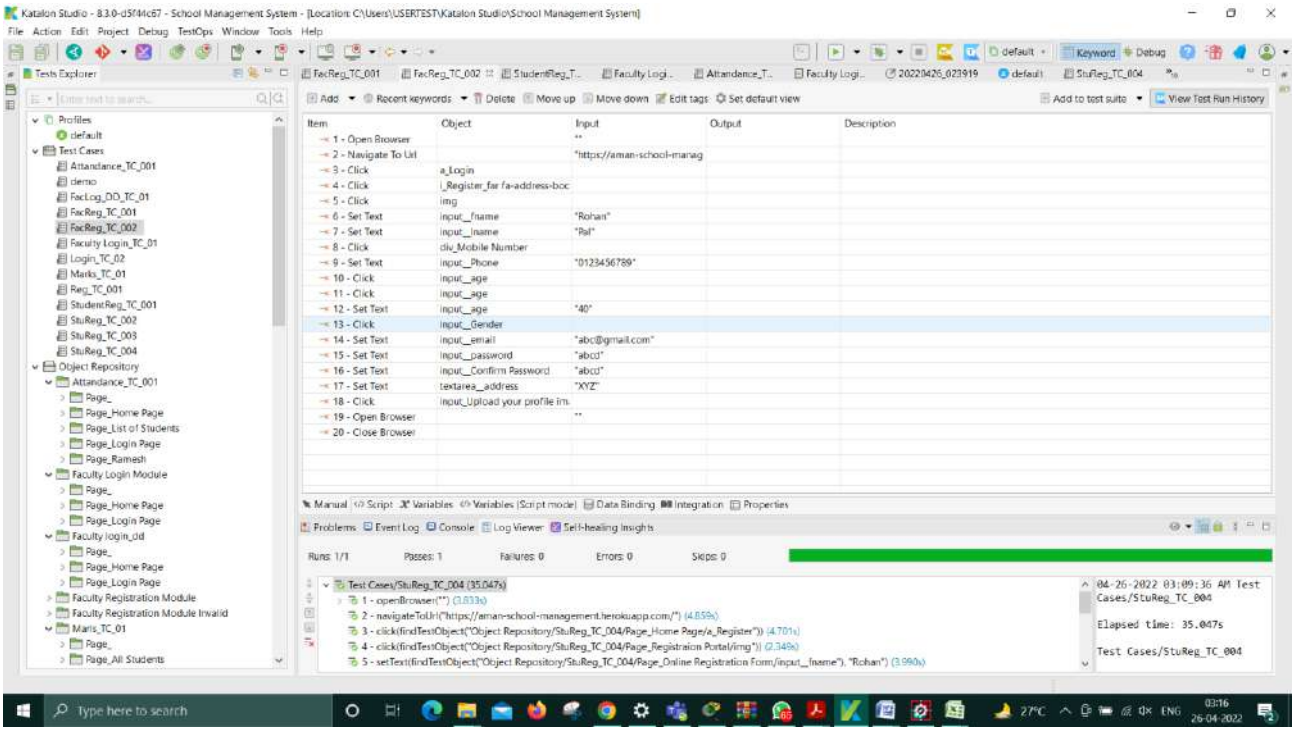
Test Cases for other Modules:

Attendance Module:

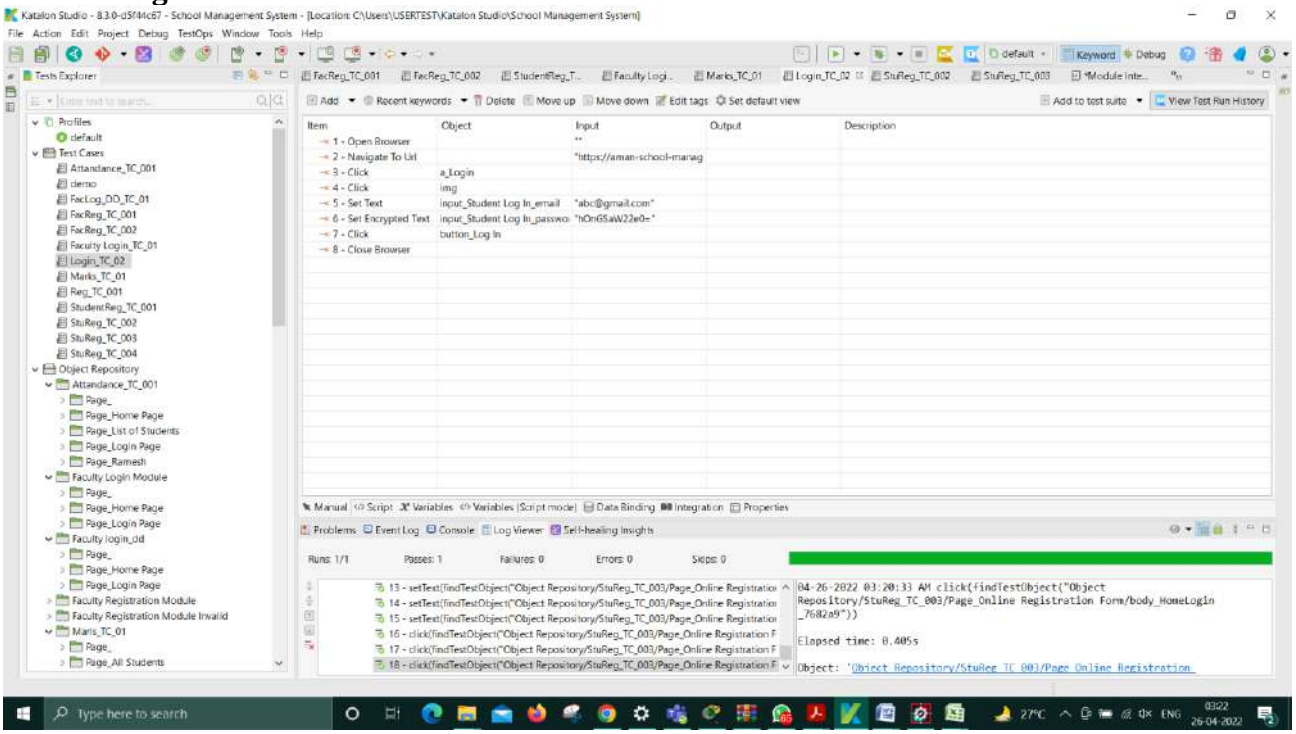


Faculty Registration Module:

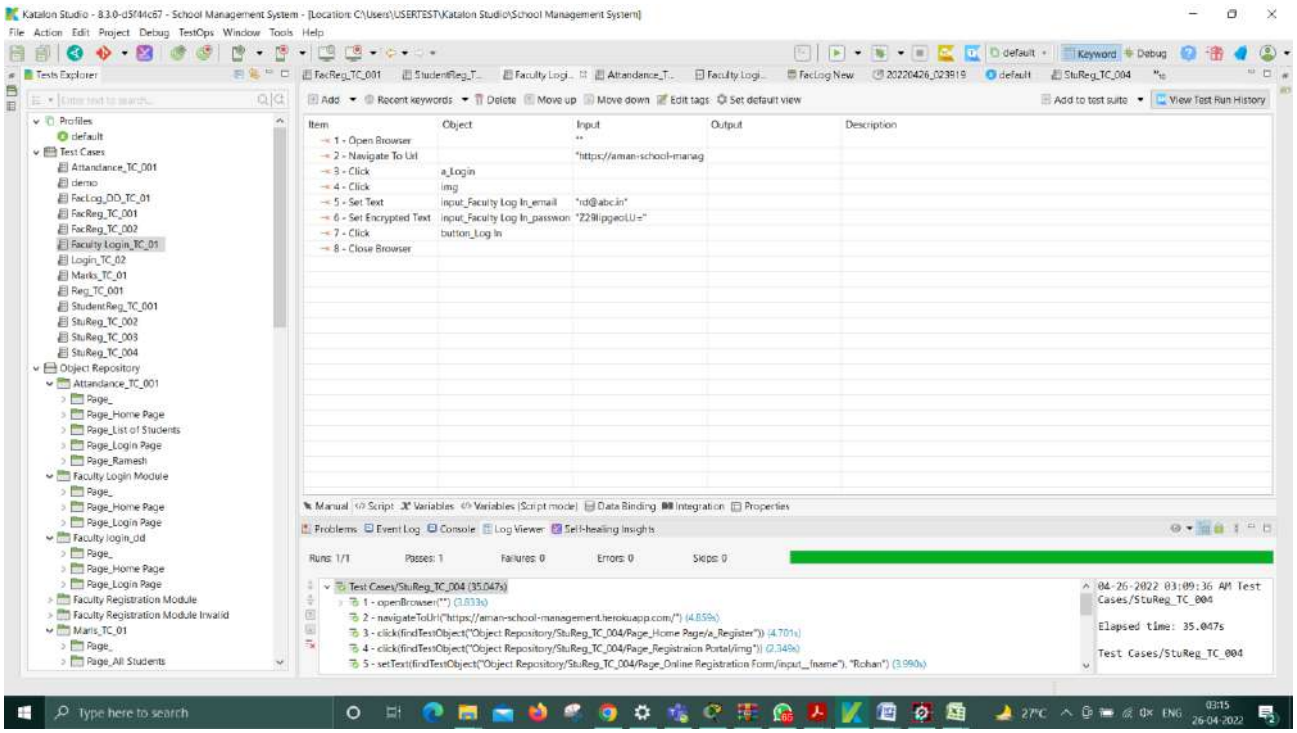




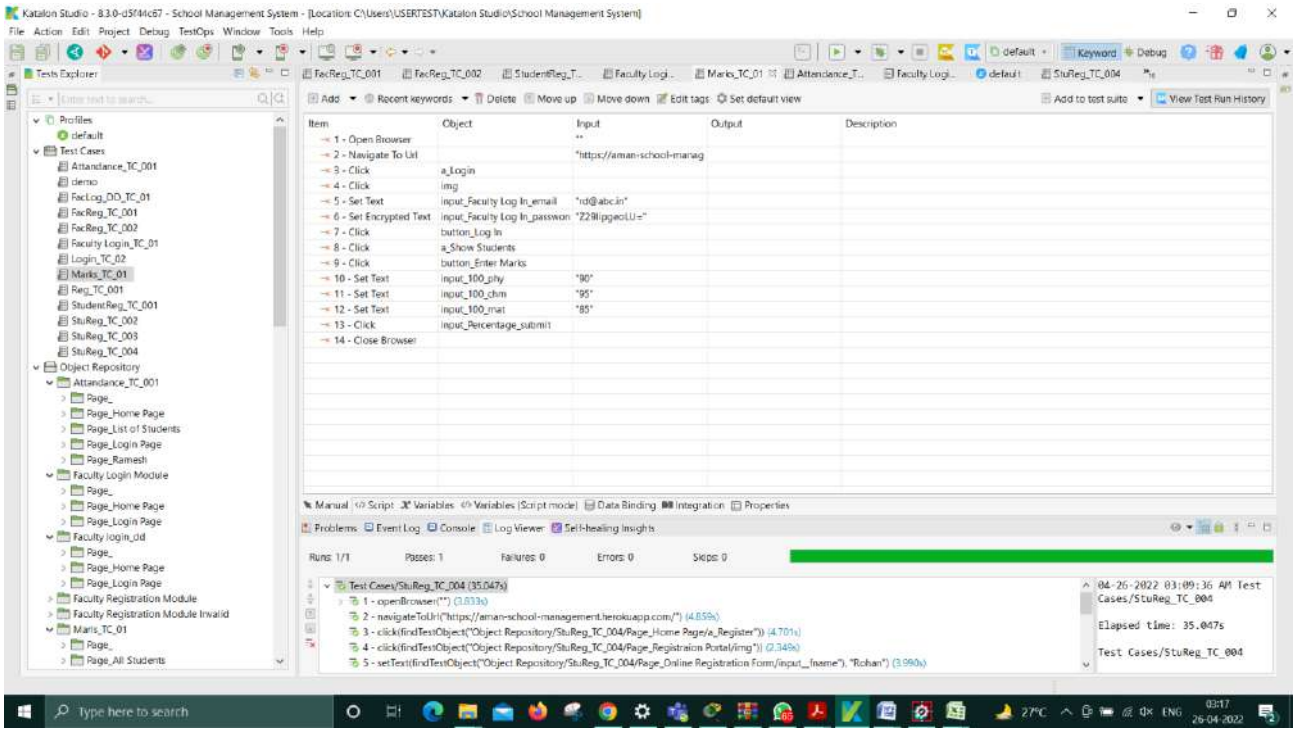
Student Login Module:



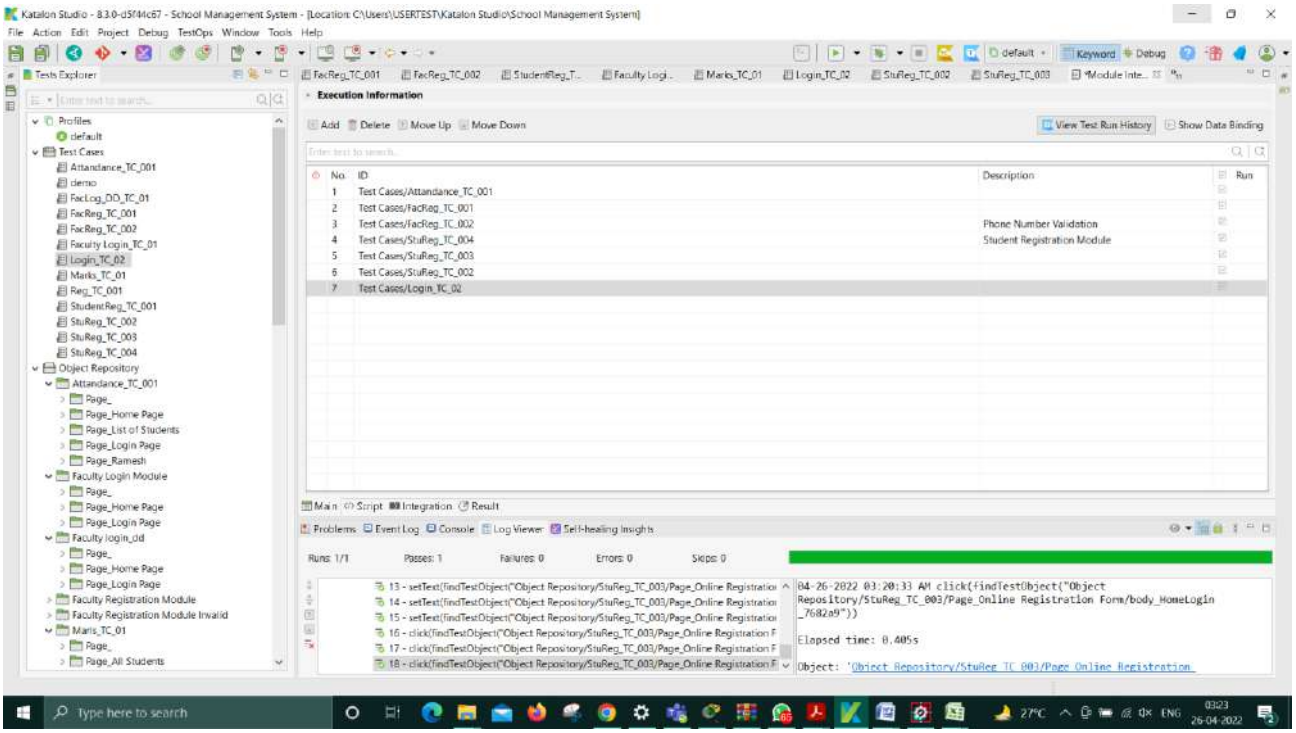
Faculty Login Module:

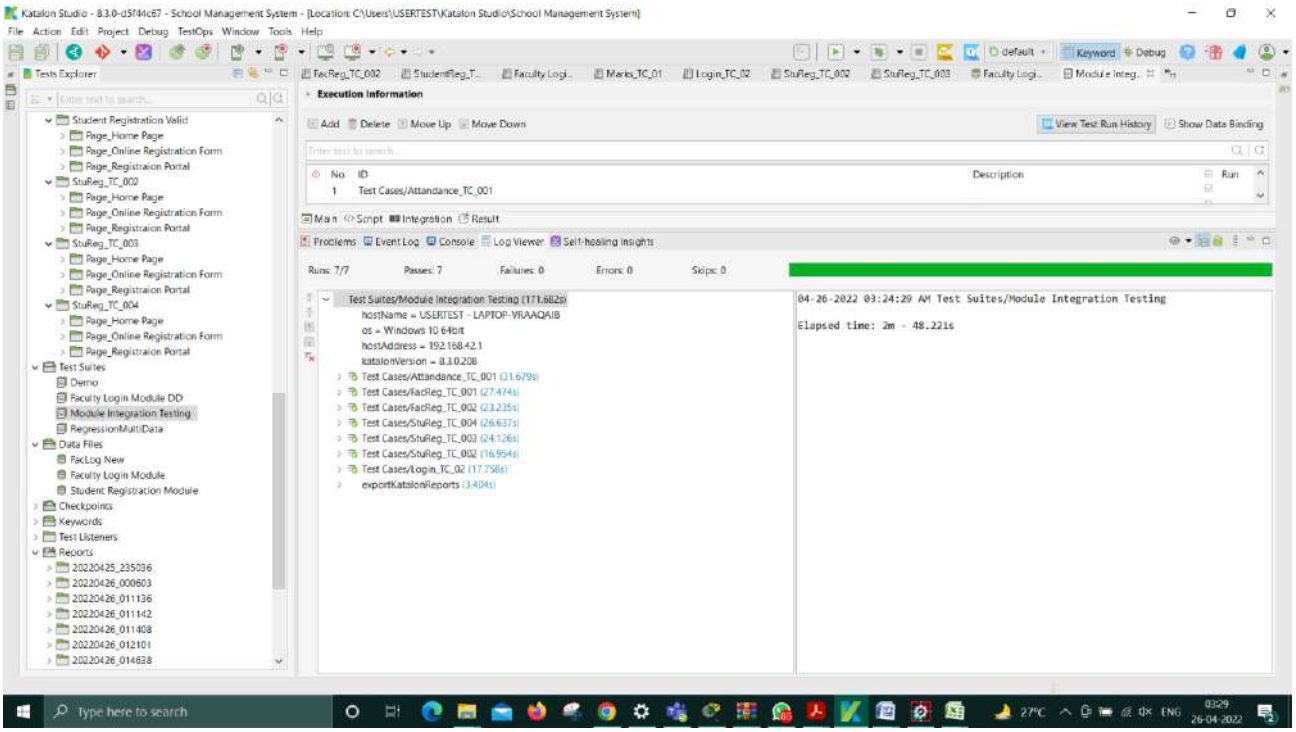


Marks Module:



Test Suite Result Analysis:

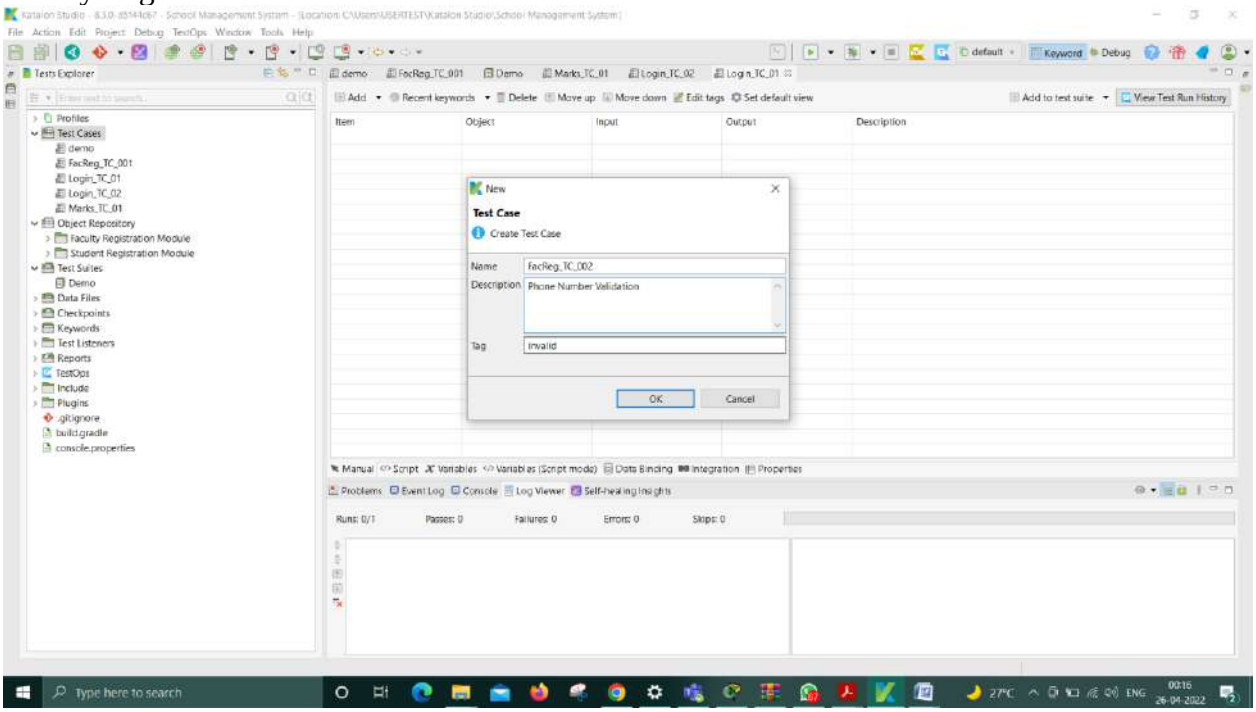




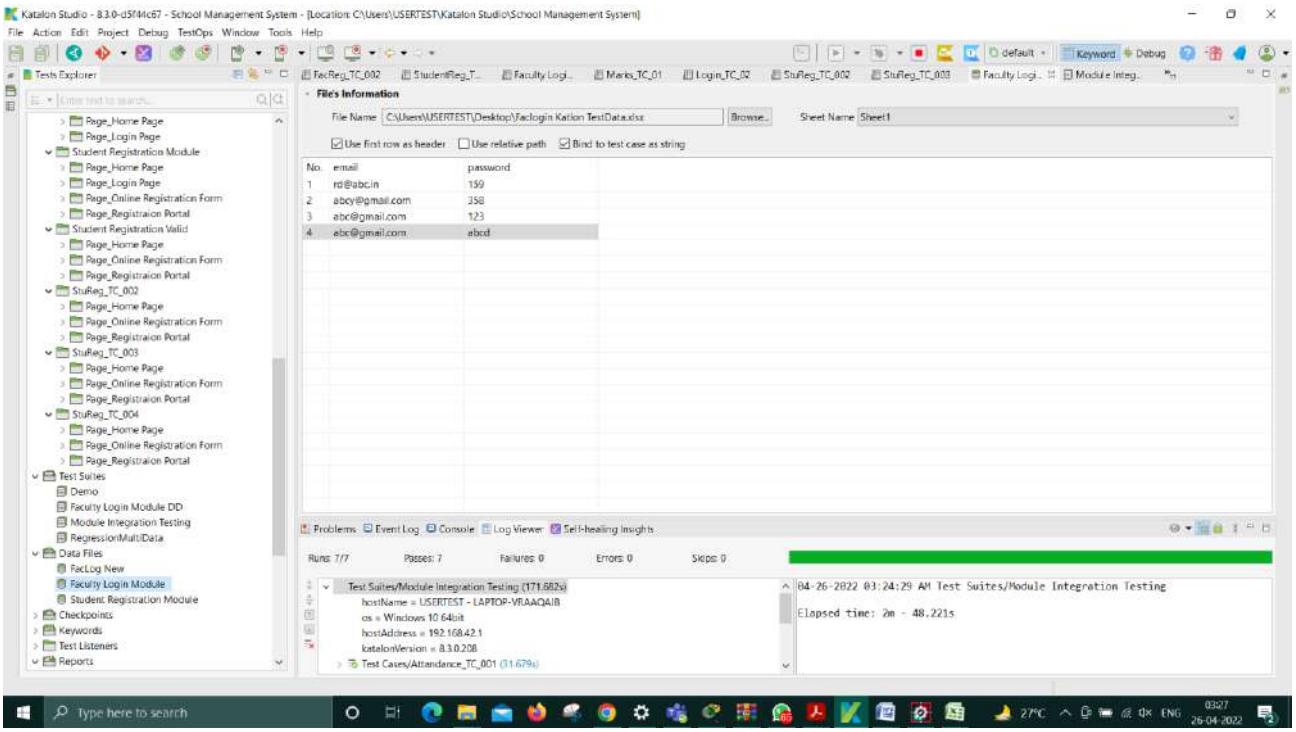
Data Driven Testing:

Data Driven Testing is a software testing technique that stores test data in a table or spreadsheet format. Testers can use data driven testing to enter a single test script that can run tests for all test data from a table and expect the test results to be returned in the same table. It's also known as parameterized testing or table-driven testing.

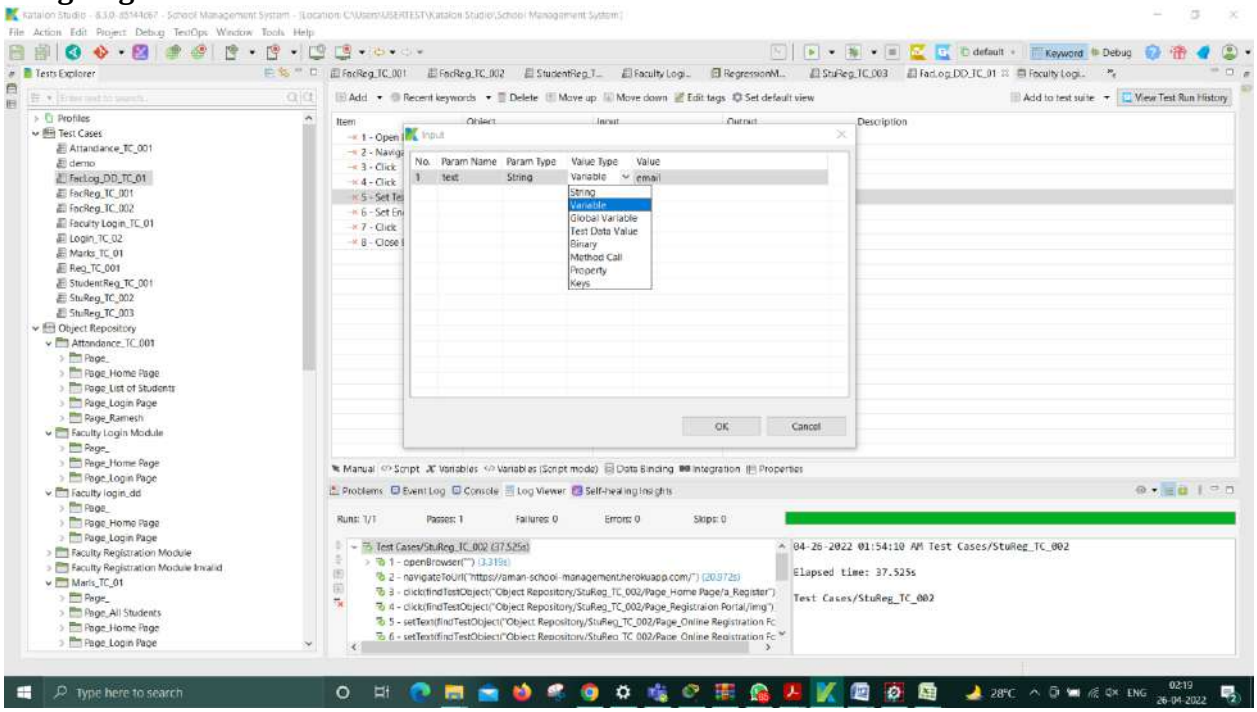
Faculty Registration Module:

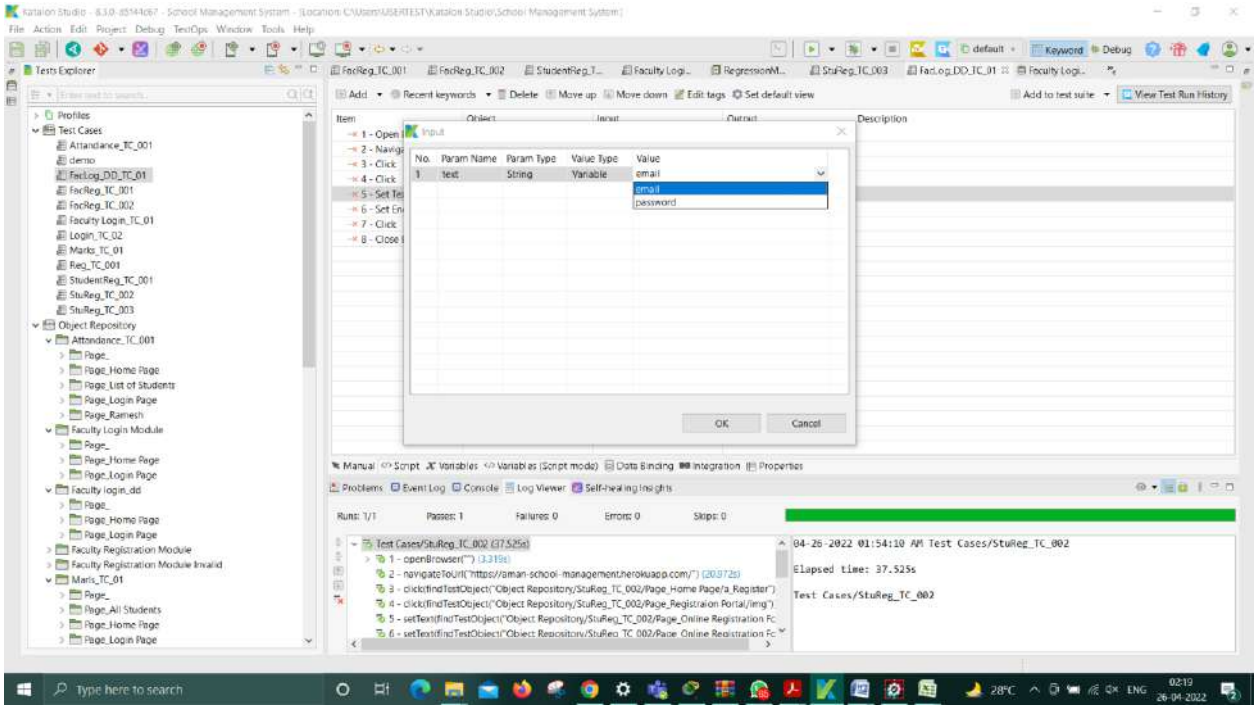


Loading Test Data in data files where data type is in excel format:

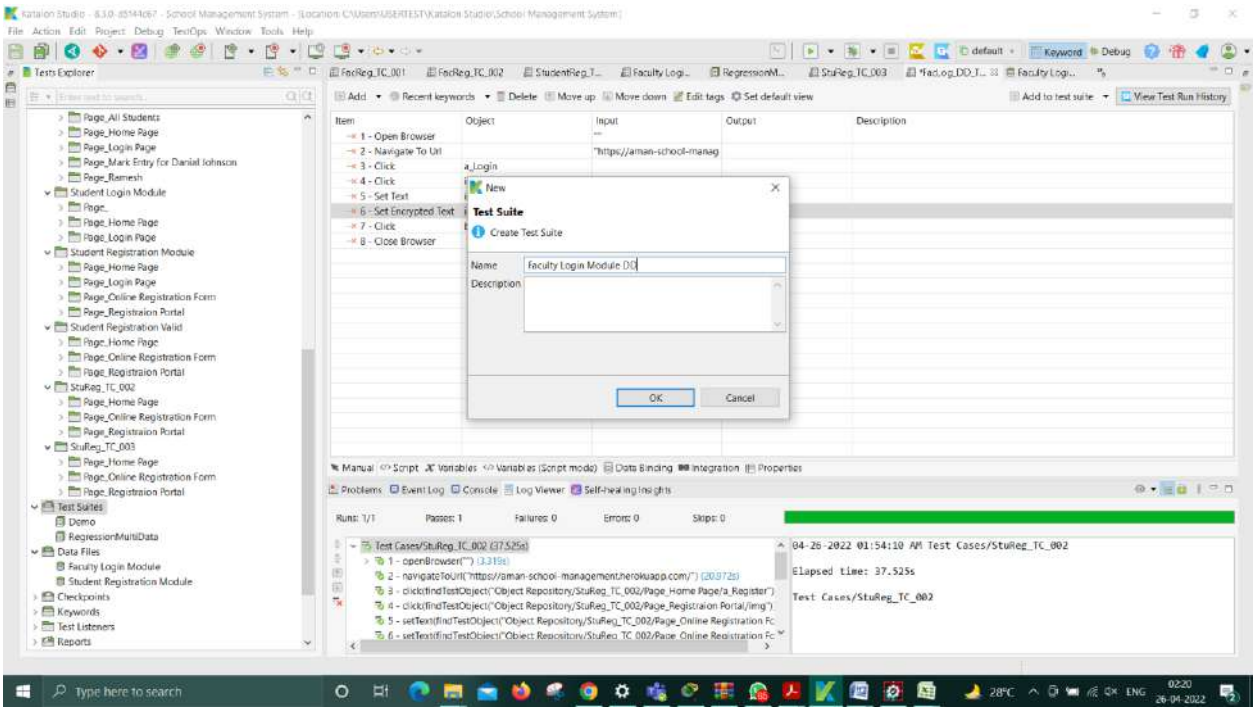


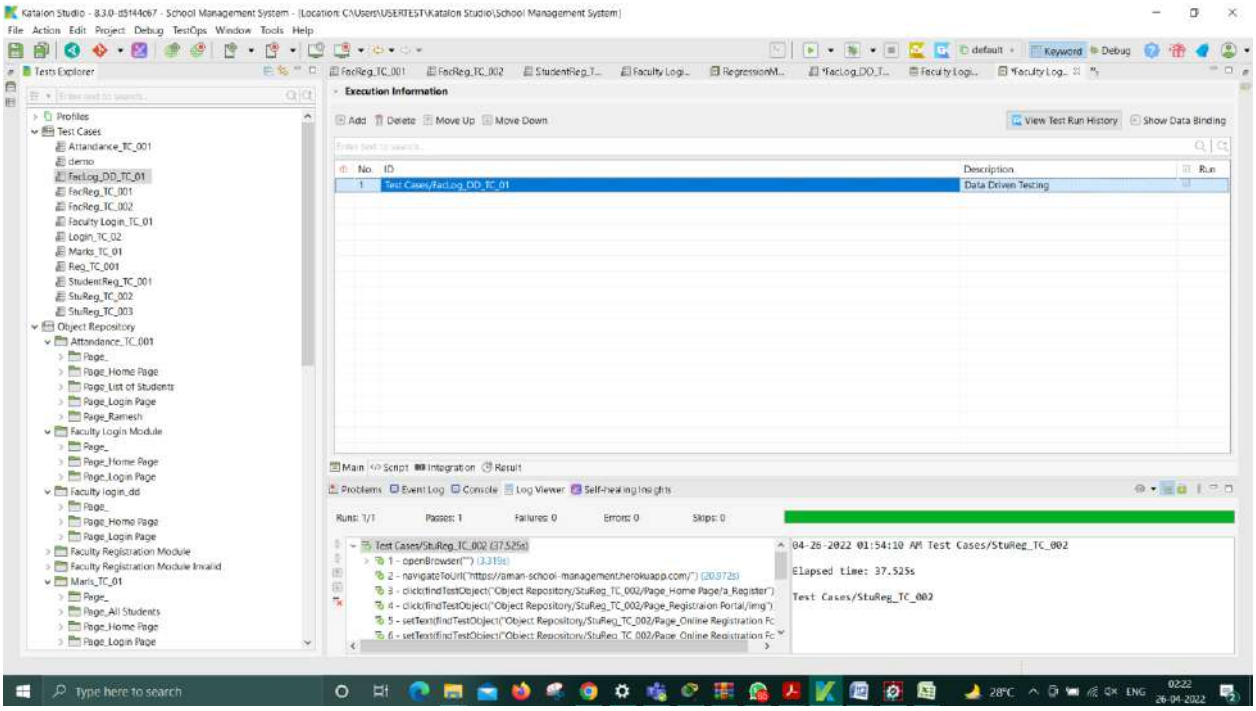
Assigning Variables:



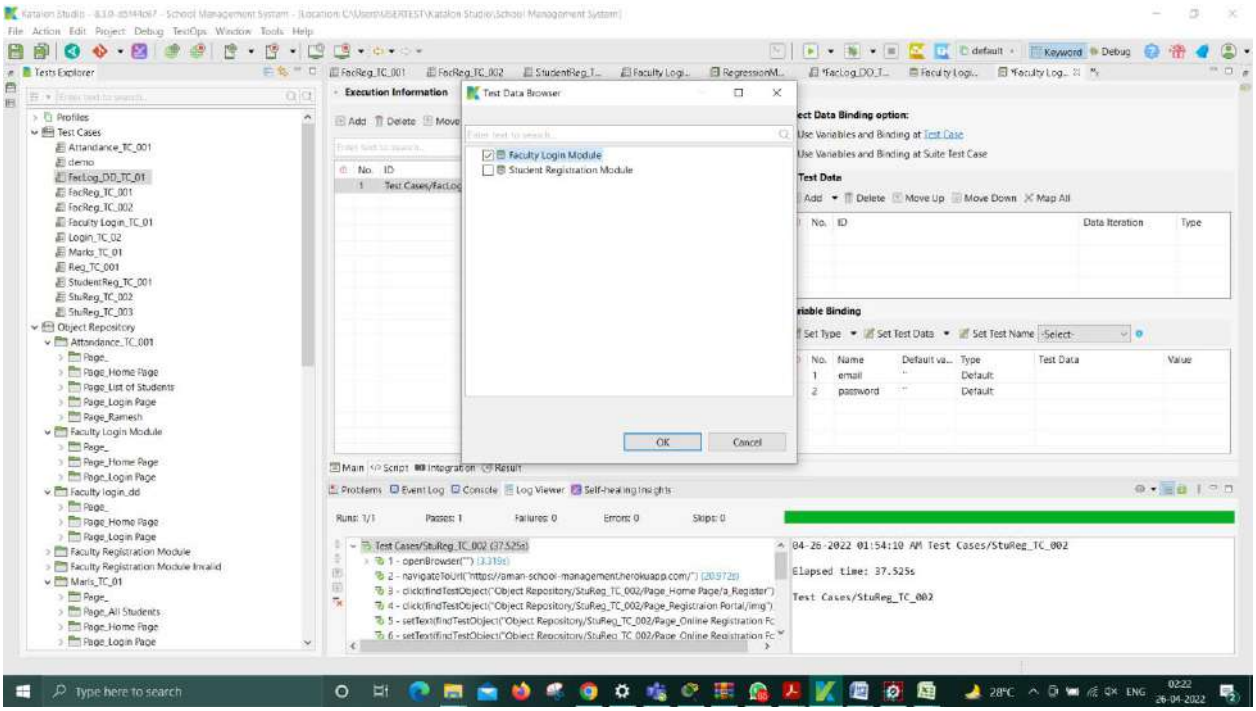


Creating Test Suite and add particular Test case:

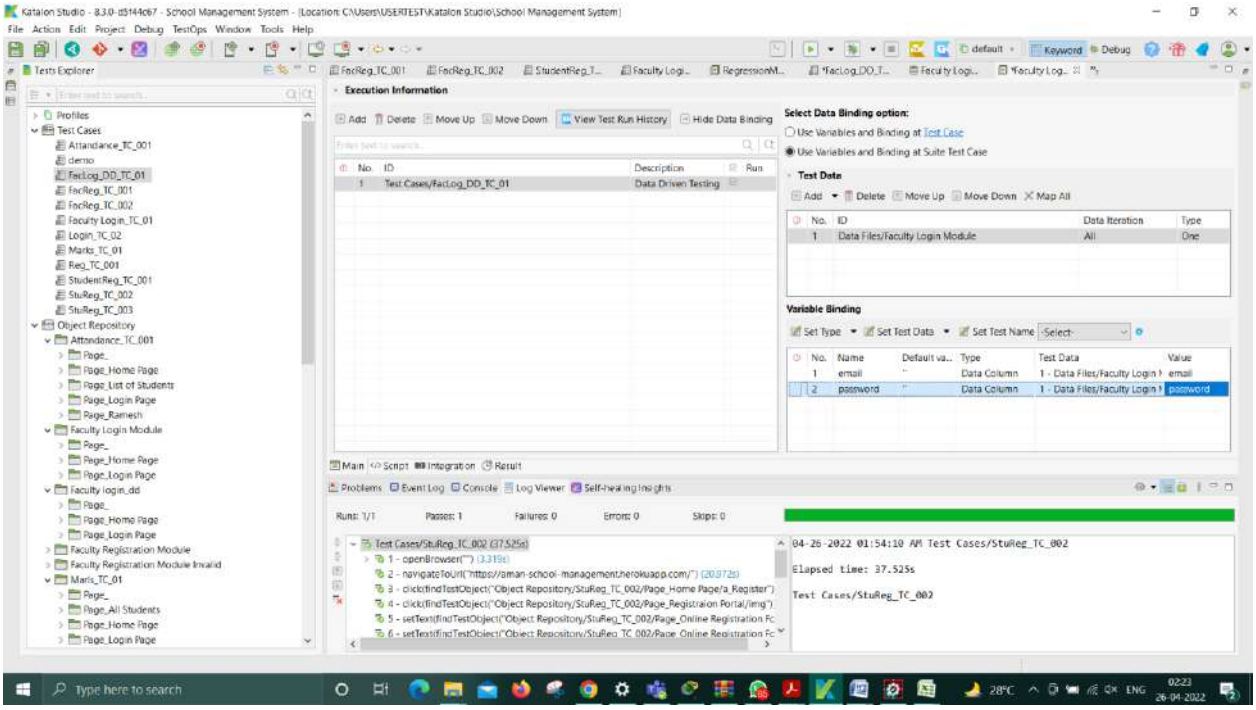




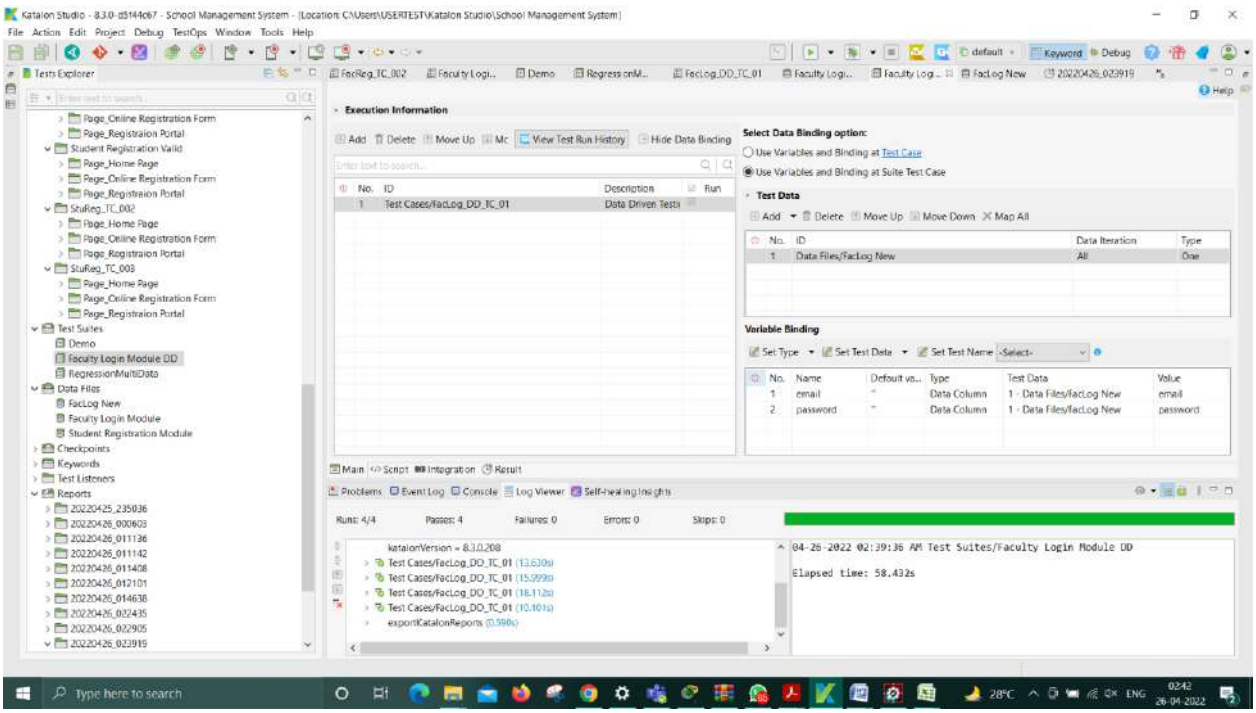
Adding Data Bindings:



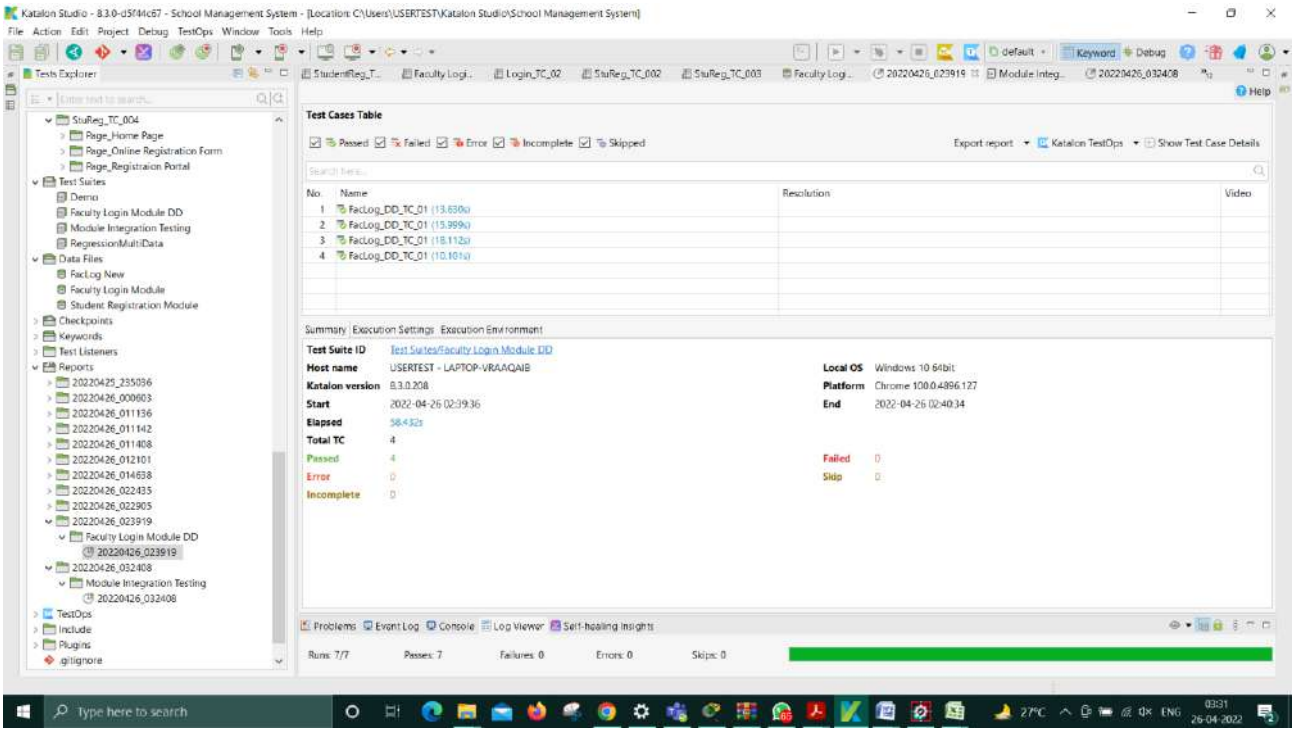
Adding Variable Binding:



Executing the test suite on chrome browser:



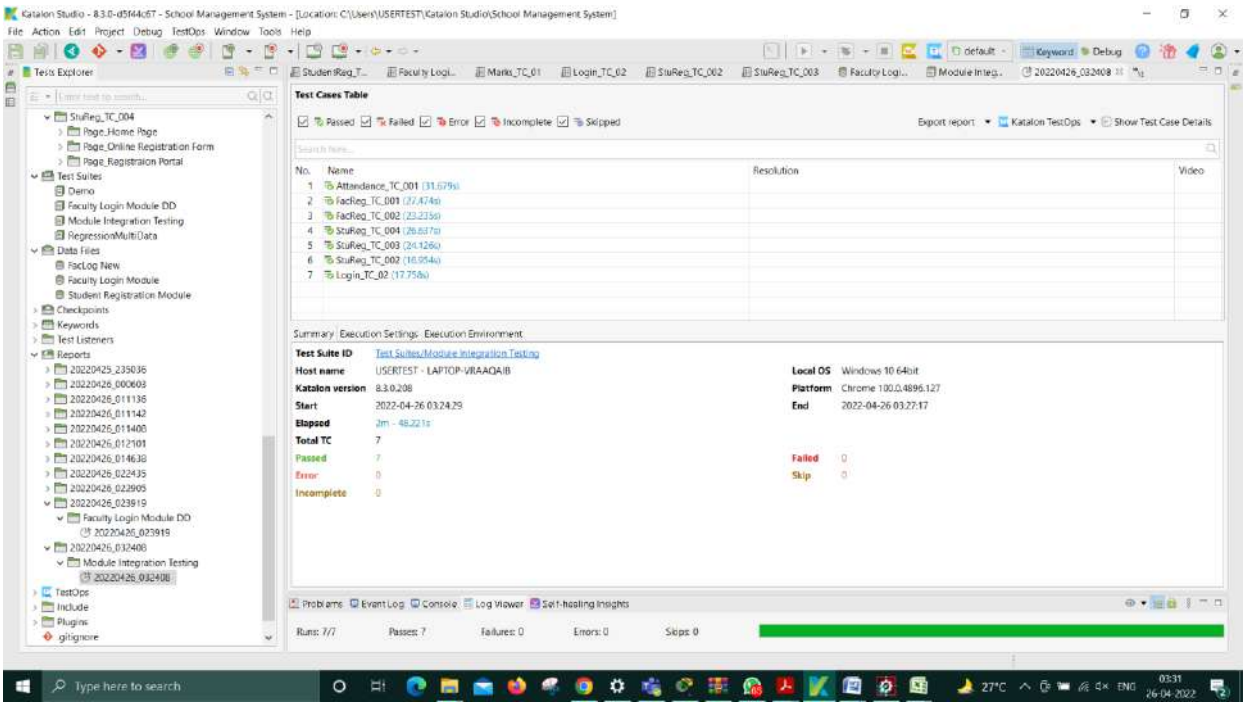
Final Report of Data Driven Testing on Faculty Login Module:



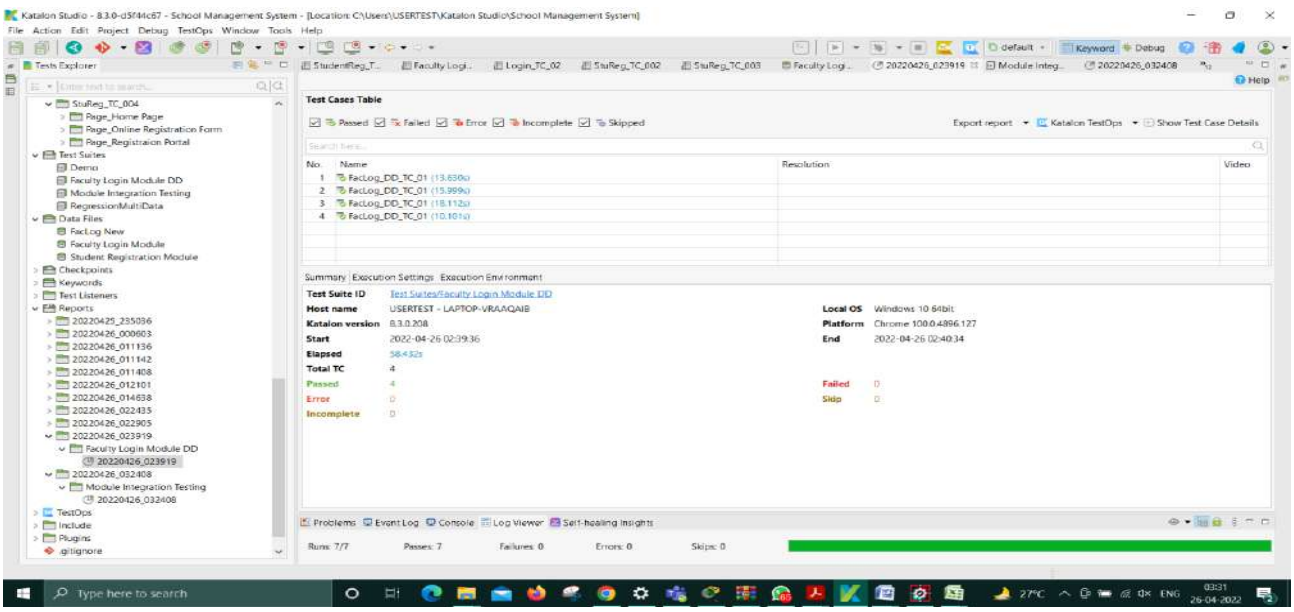
Result analysis:

Test cases for Faculty Registration, Student Registration Faculty Login, Student Login, and Attendance Modules are recorded and tested successfully passed. As we can see 7 out of 7 test cases have been passed depicting that these modules are fulfilling their required purpose and are coded correctly and efficiently by the us**.**

Report:



Report of Data Driven Testing: In data driven testing we have tested 4 test cases in the name of test suite FacLog_DD_TC_01 and out of which all have been passed. The report generated is shown below.



Conclusion:

In this project, we implemented and created a school management system based on javascript, node js, express, and mongodb atlas in this project, and we hosted the site on Heroku to see if it met the user's functional requirements. We tested it using the katalon studio automation testing tool, creating manual test cases to check the boundary value condition, robustness testing, and data driven testing of each module of the school management system, and analyzing the test case findings once the testing of the test suite is completed. We've come to the conclusion that all of our modules are operating in accordance with the user's specifications and code validations.

FUTURE WORK

In the future, more tests can be implemented that can check more sections of the code. Other modules with other additional advantages can be implemented and compared with the existing tests in terms of ease of use. The main program can be converted into a package and all the test files can be kept inside a test folder to organize the code in a better manner. Test driven development can be implemented effectively in this manner.

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