



Otomatik Yazılım Test Araçlarını Değerlendirmek için Karşılaştırmalı Bir Çalışma

Araştırma Makalesi/Research Article

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Özet— Yazılım kalitesi, yazılım test araçlarının etkin kullanımına bağlıdır. Yazılım geliştirme yaşam döngüsünde test sürecine ayrılan zaman ve önem artarken, hangi otomatik yazılım test aracının hangi yazılımda daha verimli olduğunu gösterecek yeterli kaynağın olmadığı görülmektedir. Bu makalenin amacı, bu kaynak açığını desteklemek için farklı test otomasyon araçlarını performans, maliyet, kullanılabilirlik vb. kategorilere göre karşılaştırarak incelemek ve değerlendirmektir. Bu amaçla en çok tercih edilen yazılım test otomasyon araçları farklı donanım özelliklerine sahip bilgisayarlarda ve farklı web sitelerinde deneyerek analiz edilmiştir. Yazılım test araçlarının aynı koşullardaki çalışma koşulları da incelenerek karşılaştırılmıştır. Bu sayede incelenen test araçlarının yeteneklerini ve özelliklerini değerlendirmek için rehberlik etmeyi amaçlıyoruz. Bu çalışmanın web sitelerinin yazılım geliştirme sürecinde test maliyetlerini ve süresini azaltmak için faydalı bir rehber olacağına inanıyoruz.

Anahtar Kelimeler— yazılım testi, otomatik test araçları, kullanıcı kabul testi

A Comparative Study for Evaluating Automated Software Testing Tools

Abstract—The quality of software depends on the use of software testing tools effectively. While the time and importance devoted to the testing process increasing in the software development lifecycle, it is seen that there are not enough resources to show which automated software testing tool is more efficient in which software. The aim of this paper is to examine and evaluate by comparing different test automation tools according to categories such as performance, cost, usability, etc. to support this resource deficit. For this purpose, the most preferred software test automation tools have been analyzed by experimenting on computers with different hardware specifications and different websites. Operating conditions of software testing tools under the same conditions are also examined and compared. In this way, we aim to make guidance to evaluate the capabilities and properties of examined testing tools. We believe that this study will be a useful guide for reducing testing costs and time in the software developing process of websites.

Keywords— software testing, automated testing tools, user acceptance testing

1. INTRODUCTION

Awareness of the importance of software management and quality has also increased with the increasing use of computer software [1-2]. Software testing is a part of software engineering related to the quality of the delivered product. The test is used to verify, validate, and estimate the reliability of software products to ensure software quality. Because, when the quality of the software systems

fails, disastrous results may occur. As a result of all these issues, the number of people and time allocated to the software testing process has been increased since the late 1970s. Thus, the software testing has become one of the most difficult and inevitable process for companies, organizations, researchers, as the software products are spread to a wide range of applications from daily life to mission-critical systems, depending on the ever-increasing needs [3]. There are many things to consider about

software testing from front to back-end testing [4]. There are various software testing techniques either functional or non-functional techniques. Functional testing techniques include the following methods to be applied in order: unit testing, integration testing, system testing and acceptance testing. Non-functional testing techniques include the following methods which relate to the operational aspects of a piece of software: performance testing, security testing, usability testing and compatibility testing. The basics for software testing are that whether the selected test techniques are correct for a particular software, which test types/methods should be used, what are the software requirements, which technique should be used for verification and validation, how to conduct a scope test, what document test procedures should be done, and etc [5].

Software tests can be done manually or automatically [6]. In Manual Software Testing, the process requires human input, analysis, and evaluation. Manual tests are about human intervention and are naturally vulnerable. Because most of the time, people get tired of doing the test again and again. In the manual testing process, it is necessary to write test scenarios to check the correctness of the software, which takes a lot of time and patience. Automated Software Testing is a process in which test activities are automated, including the development of test scenarios, the execution and verification of test scenarios, and the use of automated tools.

In the Automated Software Test, all tests can be automated or only some test cases can be automated. Most software companies use automated software testing to gain benefits such as quality improvement, time to market, and less human effort. Achieving efficient automated software testing is dependent on performing tests in less time and with less effort. This is related to the selection of the "software automation test tool" to be used. "Software automation test tools" developed for use in the automated testing process show different properties among themselves according to their usage areas. For instance, while some are used for mobile applications, some are used for testing websites. Besides, these test automation tools differ depending on the programming languages and test methods used.

There are many automated testing tools developed over the years. However, this situation makes it difficult for users to decide which test tool to use. There are several studies in the literature that automatic testing tools are examined and evaluated [7-26]. Although these studies are very valuable in the field of automated software testing tools, they do not cover the testing aspects such as test levels, interfaces used, performance analysis, ease of use, code requirements. This research gap that needs to be filled is the motivation of this study.

This paper aims to present a resource that will make it easier for individuals and institutions to choose the right automated test tool to test websites. For this purpose, some test automation tools on the market are discussed. These tools are selected according to the most preferred test

automation tools based on the choices of the users in the market [27-30]. The test automation tools examined are the most popular six tools used to test websites.

2. LITERATURE REVIEW

Regarding the categorization of Automated Software Testing tools, an automatic test model was proposed to classify test tools in the study published by Sergey Uspenskiy [13]. Berner found that the vast majority of software errors were detected during the manual software testing process [12]. The reason for this is that 60% of software bugs are found with automatic testing tools and 80% are found while developing software testing. The benefits and difficulties of automated software test tools, consistency, and repeatability of these tests, reusability of the tests, expectations from automated test tools, their place in the economic market, the scope for further research are the topics covered by related research studies in the literature [7-15]. In the study of Polamreddy and Irtaza, the comparison of Test Case Based Testing and Model-Based Testing was done in terms of providing better test coverage, requirement traceability, cost, and time [16]. Chitrala measured the effectiveness of the automated testing tools Tpalus and Evosuite in his thesis [17]. Shtakova evaluated some automated testing tools based on some criteria applying them to the large-scale financial system "Scila Surveillance" [18]. Atesogullari and Mishra presented a comparison of twenty-one test automation tools on twenty attributes [19]. Khalid proposed a technique to build an automated software testing tool to test the source code (in C++ Language) of any software. Also, a comparison of this tool with the commercial testing software was presented [20]. Imran, Hebaishy et al., presented a comparative study for the test automation tools Load Runner and Quick Test Professional in terms of cost, execution speed, ease of learning, test result report, recording and playback, data-driven testing and script generation capability [21]. Rajamanickam provided information about the features and importance of some automated web testing tools in his study [22]. In the study of Shaukat et al., the taxonomy of several automated testing tools based on their distinct features was presented [23]. Dandan introduced a method to generate an automated test case based on a software business process chart in his study [24]. Mohammad, D., et al., evaluated different automated testing tools for mobile applications on windows platform to ensure quality of the mobile applications and to measure testability and performance of these applications [25].

3. MATERIALS AND METHODS

The determined websites are given in Table 1. Test scenarios are created as given in Table 2 and the test automation tools are run through these scenarios for the purpose served by the site. The selected test automation tools are given in Table 3.

There is no priority criterion for the determination of the websites, the websites with dense textual or visual content are preferred.

Table 1. The websites tested in the study

Web Site	Web Site Type	Web Address
TRT World	News	www.trtworld.com
BBC World	News	www.bbc.com
The New York Times	News	www.nytimes.com
Tom's Hardware	Forum	forums.tomshardware.com
Linus Tech Tips	Forum	linustechtips.com/main/
xda Developers	Forum	forum.xda-developers.com
Twitter	Social Media	twitter.com
Deviantart	Visual Sharing	www.deviantart.com
YouTube	Video Sharing	www.youtube.com
Amazon	Shopping	www.amazon.com
HepsiBurada	Shopping	www.hepsiburada.com

The tested websites are publicly open and since a scenario and testing process for bug detection will distort the study in terms of method (End-user experience - User Acceptance Test logic), the bug detecting is not included into this study. However, all of the tools used in the study can detect the bugs of websites, such as 'not opening the web page', 'server crash', 'deletion of the web page', 'inaccessibility to the user', 'inability to share', 'file cannot be found', 'validation fields' and 'crashes caused by button clicks'. Also, the testing scenarios are created based on the client-side. Because, server-side tests do not cover end-user experience evaluations that are the content of the study.

Table 2. Walkthrough on the test websites

Tested Web Site	Walkthrough
TRT World	Go to website> Click the Opinion link> Click the Must-See link> Check for the correct page
BBC World	Go to website> Click on the Weather link> Search for Istanbul in the search bar> Check for the correct result
The New York Times	Go to website> Click on the Sports link> Click on the Tennis link> Check for the correct page
Tom's Hardware	Go to website> Login with current account> Return to homepage> Check if you are logged in with the correct user on the home page
Linus Tech Tips	Go to website> Login with current account> Return to homepage> Check if you are logged in with the correct user on the home page
xda Developers	Go to website> Login with current account> Return to homepage> Check if you are logged in with the correct user on the home page
Twitter	Go to website > Login with current account> Write Tweet using a specific hashtag> Update home page> Find and click hashtag> Check if the page related to the hashtag has been opened
Deviantart	Go to website > Search images with a specific word> Open the third image on the search result page that opens and save to the device> Manually check if the related image has been saved

YouTube	Go to website> Search for a specific video> Open related video>
Amazon	Stop video> Check if the correct video is opened and stopped
HepsiBurada	Go to website> Search for a specific product> Enter the page of the relevant product> Add the product to the wish list> Open the wish list> Check whether the relevant product is in the wish list.

Determination of the test automation tools to be used was made by selecting six of the most preferred test tools according to some websites related to software testing [27-30]. The latest versions of them are used in the study.

Table 3. The test automation tools used in the study

Used Tools	Version
Selenium WebDriver (with IntelliJ Java IDE)	WebDriver 3.14.0
Katalon Studio	5.7.1
Telerik Test Studio	2018.2.606.0
Ranorex Studio	8.2.1
Squish	IDE 6.4.1
TestingWhiz	6.1.1: Saturn

All of these test automation tools are installed on the devices specified in Table 4. The devices are used to meet the minimum system requirements of all devices. The test environment is carried out on two computers with different hardware features but on the same browsers. These computers are named PC-1 and PC-2 in the study.

Table 4. The computers and specifications used in the study

	PC-1	PC-2
Processor (CPU)	Intel Core i5- 4590 (3.30 Ghz)	Intel Core m3- 7Y30 (1.00 Ghz)
Memory (RAM)	16GB DDR3	4GB LPDDR3
Storage	SSD (for browsers) HDD (for test automation tools)	SSD (for browsers) HDD (for test automation tools)
Resolution	1920x1080	1920x1280
Operating System (OS)	Windows 10 Education	Windows 10 Home
Web Browser	Mozilla Firefox v61-62 (64-bit)	
	Google Chrome v69 (64-bit)	

4. RESULTS

Coding knowledge requirements of the Test Automation Tools used in the study are given in Table 5. Coding knowledge needed is evaluated out of 5. '1' is used for situations where simple UI tests can be performed without requiring any coding knowledge, and '5' means that knowing the required script language or HTML knowledge at medium and higher levels provides great advantages. This evaluation was made based on the features of the tools and the experience of the user according to the criteria such as how much code to write when using the tool, can the tool

be used completely without coding, or is it necessary to interfere with the code.

Table 5. Coding knowledge requirement evaluation

Testing Tool	Coding Knowledge	Supported Languages
Selenium WebDriver	5	Java, C#, Perl, Python, JavaScript, Ruby, PHP
Katalon Studio	3	Java/Groovy, JavaScript
Telerik Test Studio	1	C#, VB.NET
Ranorex Studio	2	C#, VB.NET
Squish	4	JavaScript, Perl, Python, Ruby
TestingWhiz	5	Java

During the determined tools are running in both scanners on the computers PC1 and PC2, the average values of the processor (CPU) and memory (RAM) usage were calculated by recording video with Windows 10 Task Manager. Only the use of each tool evaluated during this process is included (together with IntelliJ IDEA for Selenium), and the load on the system is not taken into account. No other applications that would put any load on computers in the background or interfere with the operation of the vehicles were run during the run. Web browsers were reset before each harness and the effect of cookies and temporary files was tried to be reduced. The test scenario of the same website was run 10 (ten) times in total for each device and average values were calculated. The pre-prepared scenarios with the determined websites and test automation tools are based on the end-user experience (with the logic of the User Acceptance Test). During the testing of test scenarios, the Record and Playback feature was used for all testing tools except Selenium WebDriver, and coding was not used.

Average CPU and RAM usage of the test automation tools according to the devices are given in Table 6.

Table 6. CPU and RAM usage of test automation tools according to computer type

Testing Tool	Computer	CPU (%)	RAM (%)
Selenium WebDriver	PC-1	7	5
	PC-2	12	22
Katalon Studio	PC-1	13	6
	PC-2	35	20
Telerik Test Studio	PC-1	1	1
	PC-2	1	2
Ranorex Studio	PC-1	1	1
	PC-2	2	3
Squish	PC-1	2	3
	PC-2	3	12
TestingWhiz	PC-1	5	1
	PC-2	14	6

It has been observed that Selenium WebDriver is running out of CPU and RAM in the low-equipped computer, especially on websites containing many items on one page

when operating with the help of IntelliJ IDE, but still has not lost its functionality.

Katalon Studio has been observed to perform similarly in all scenarios, regardless of the website content. It was observed that the vehicle's high-end system tired as much as the low-end system, and was particularly heavy in terms of CPU usage.

It has been observed that Telerik Test Studio performs similarly and effectively in all scenarios regardless of website content. CPU and RAM usage of the vehicle gives close values in both devices and provides minimum usage without tiring the system.

Table 7. CPU and RAM usage of test automation tools according to website type

Testing Tool	Web Site Type	CPU (%)	RAM (%)
Selenium WebDriver	News	11,23	13,22
	Forum	8,00	12,03
	Social Media	5,15	13,95
	Visual Sharing	11,80	13,85
	Video Sharing	10,95	11,75
	Shopping	9,83	15,38
Katalon Studio	News	20,47	14,73
	Forum	19,40	13,23
	Social Media	21,15	17,30
	Visual Sharing	23,30	16,45
	Video Sharing	26,55	14,50
	Shopping	25,35	12,15
Telerik Test Studio	News	0,93	1,62
	Forum	0,95	1,38
	Social Media	0,80	1,40
	Visual Sharing	1,15	1,55
	Video Sharing	0,95	1,60
	Shopping	1,05	1,55
Ranorex Studio	News	1,23	1,72
	Forum	1,35	1,95
	Social Media	1,15	1,20
	Visual Sharing	1,15	1,85
	Video Sharing	1,60	2,05
	Shopping	1,30	1,63
Squish	News	2,35	7,47
	Forum	4,00	6,45
	Social Media	2,45	7,55
	Visual Sharing	3,30	6,90
	Video Sharing	2,40	2,70
	Shopping	1,85	10,70
TestingWhiz	News	11,88	3,57
	Forum	11,47	3,53
	Social Media	8,90	2,60
	Visual Sharing	9,50	4,15
	Video Sharing	7,20	4,00
	Shopping	10,70	4,23

It has been observed that Ranorex Studio has increased RAM usage values on websites with text density. This difference is particularly evident in a low-end computer. In addition, it has been observed that Ranorex Studio increases CPU usage in visual content sites. Despite this, the vehicle continued its functionality without tiring the system on both devices.

It has been observed that Squish increased the usage of RAM especially in the low-end computer and started to exhaust the system in terms of RAM. The tool used variable RAM regardless of website content regardless of any condition. Although the CPU uses are close to each other, the reason for the changes in RAM usage could not be determined clearly.

TestingWhiz has been observed to force the CPU and leave RAM in light use, especially on text-heavy websites. CPU usage increased to 20% levels, especially in the low-end computer, which put a heavy load on the system. The CPU usage is close to each other and it is observed that it does not force the system too much.

Average CPU and RAM usage of the test automation tools according to the website type in the study are given in Table 7.

Based on these values; It was observed that Katalon Studio put a lot of load on the system on a low-equipped computer, Ranorex Studio continued to work on both computers without tiring the hardware, and although Selenium was used with IDE, it was not in a very bad situation in terms of the load put on the system. As a result, it has been observed that Telerik Test Studio uses at least CPU and RAM and is more effective than other test automation tools in the study.

Some of test automation tools which are used in this study provide data-driven test, and some of them provide directly database testing. Since the database tests are not mentioned in the scenarios, they were examined theoretically as follows:

In order to use Selenium WebDriver for Database Verification, we need to use the JDBC (Java Database Connectivity). JDBC (Java Database Connectivity) is a SQL-level API that allows us to execute SQL statements. It is responsible for the connectivity between the Java Programming language and a wide range of databases. The JDBC API provides some classes and interfaces such as Driver Manager, Driver, Connection, Statement, ResultSet, SQLException.

Katalon Studio supports data-driven testing with several methods that allow test scripts to read inputs from internal or external data files. Particularly, in Katalon test cases, test objects or their properties can be parameterized as placeholders and receive values during execution. Users can design data-driven test scripts in Katalon Studio with

Web Test Objects Parameterization which is a specific feature of Katalon Studio.

Telerik Test Studio can be used for data-driven testing. It supports five different data sources such as Local Data Source, Excel spreadsheet, XML file, CSV file, SQL database by binding test to a data source.

Ranorex Studio uses a test container (test case/smart folder) to retrieve input values from a data source such as an Excel spreadsheet or a database file in data-driven testing. The test container is then repeated automatically for each row of data in the data source.

Squish provides data-driven testing by running tests using a variety of supported data sources including TSV, CSV, TXT, Microsoft Excel spreadsheets, Databases. Users should implement a data-driven GUI test to run these tests. Also, Squish IDE can refactor the code to accommodate the new input data.

TestingWhiz helps check the overall health and stability of databases, stored as master data as well as procedures and business logic to ensure quality performance and continuous contribution to key business processes with database test automation capability. It provides a diagnosis of a specific database on a server, industry-standard benchmarks testing of databases, managing and governing database resources, and their utilization.

TestingWhiz may help to automate the comparison of two different data sets to verify the integrity of the data and ensure accurate reporting by running queries to look up if the data has been processed correctly or not, detailed drill-down information for database testing errors and data divergence or data mirroring with different data versions. TestingWhiz also offers quick and easy database validation solution to authenticate various databases and their quality for further usage and analysis by doing validation of database server configuration, doing verification of database server load and determining/authentication of database end-users.

The qualifications considered in the following part of the study are "Ease of Use", "Code Requirement", "Reporting", "Pricing", "Support", "Documentation and Education", "DevOps/Agile Planning Support".

The score of "Ease of Use" is based on the criteria as "Installing and Running the Tool", "Interface Design" and "Test Setup and Test Running". Final score is obtained by adding the evaluation scores of each criterion. Evaluation scores of each criterion are as follows: *Installing and Running the Tool*: 1 point- Very laborious and challenging; 2 points- Simple and effortless. *Interface Design*: 1 point-no interface and has own IDE, 2 points- resembles the IDE interface or hard to understand, 3 points-simple but time needed to learn; 4 points-simple, user-friendly interface.

Test Setup and Test Running: 1 point- requires code information and plugins; 2 points- requires plugins to setup a test environment or has too many steps to create a new project; 3 points- provides creating scenarios step by step; 4 points- few simple commands on interface is enough for running a test.

The score of “Code Requirement” is based on the criteria as “*Supported Languages*”, “*Knowledge Requirement for Languages*” and “*Code Usage*”. Final score is obtained by adding the evaluation scores of each criterion. Evaluation scores of each criterion are as follows:

Supported Languages: 1 point- supports few or not highly preferred languages; 2 points- supports few but popular languages; 3 points- supports several and popular languages.

Knowledge Requirement for Languages: 1 point- requires above starter/high knowledge on supported languages, 2 points- requires basic knowledge on supported language; 3 points- requires knowledge of few basic commands; 4 points- does not require any code knowledge.

Code Usage: 1 point- requires code knowledge as writing a software; 2 points- can need intervention with codes sometimes; 3 points- can run tests without using code.

The score of “Reporting” is based on the criteria as “*Report Details*”, “*Report Readability*” and “*Report Content*”. Final score is obtained by adding the evaluation scores of each criterion. Evaluation scores of each criterion are as follows:

Report Details: 1 point- not detailed; 2 points- detailed but does not give solution; 3 points- not detailed but can help to find a solution; 4 points- detailed and show reasons of errors.

Report Readability: 1 point- requires code knowledge to read reports; 2 points- requires knowledge of technical terms; 3 points- creates easily readable reports for every level of knowledge.

Report Content: 1 point- plain and without sufficient information or with error codes; 2 points- creates detailed but non-categorized or categorized but not detailed reports; 3 points- creates detailed and categorized reports.

The score of “Pricing” is based on the criteria as “*Monthly/Annual/Periodic Price*”, “*Price/Performance Analysis*” and “*Services Include in the Price*”. Final score is obtained by adding the evaluation scores of each criterion. Evaluation scores of each criterion are as follows:

Monthly/Annual/Periodic Price: 1 point- does not have a certain price tag; 2 points- has user or usage limit; 3 points- has additional fees; 4 points- completely free

Price/Performance Analysis: 1 point- does not perform well enough for its price; 2 points- adequate for the price; 3 points- very good performance for the price.

Services Include in the Price: 1 point- no or very limited service; 2-points limited services are included in the price; 3 points- free technical supports and services.

The score of “Support” is based on the criteria as “*Support Channels*”, “*Support Times*” and “*Community*”. Final score is obtained by adding the evaluation scores of each

criterion. Evaluation scores of each criterion are as follows:

Support Channels: 1 point- does not have live support; 2 points - official but not live support; 3 points- official and live support.

Support Times: 1 point- no certain time is provided; 2 points- users can ask for support for 7/24 but accessibility is not certain; 3 points- can be accessible in working hours; 4 points- 7/24 active and accessible support.

Community: 1 point- does not have an active forum/blog; 2 points- has an active forum, but not a large community; 3 points- has active forums/blogs and a large community.

The score of “Documentation and Training” is based on the criteria as “*Training Source*”, “*Training Documents*” and “*Courses*”. Final score is obtained by adding the evaluation scores of each criterion. Evaluation scores of each criterion are as follows:

Training Source: 1 point- no official training sources; 2 points- training materials are in webinar/screencast formats; 3 points- official training videos.

Training Documents: 1 point- no free official documents; 2 points- free community documents or limited official materials; 3 points; free official documents and materials; 4 points- official documents, materials and examples.

Courses: 1 point- No courses/priced courses; 2 points- official training services; 3 points- official training courses and consultancy.

The score of “DevOps/Agile Planning Support” is based on the criteria as “*DevOps Support*” and “*Agile Planning Support*”. Final score is obtained by adding the evaluation scores of each criterion. Evaluation scores of each criterion are as follows:

DevOps Support: 1 point- not enough DevOps support; 2 points- limited DevOps support; 3 points- can be usable with many tools but needs knowledge/experience; 4 points- easy implementation/integration with limited tools; 5 points- easy implementation/integration with several tools or having own tool.

Agile Planning Support: 1 point- no support for agile planning; 2 points; uses other automation tools infrastructure; 3 points- provides planning with plugins; 4 points- provides agile planning with other tools or more popular plugins; 5 points- provides planning with other tools and track issues

Table 8 shows the usage experiences for users who will use the Selenium WebDriver tool for the first time. The ease of installing Selenium WebDriver on a device (PC1 and PC2 is taken as reference) is mentioned in the table. 'Interface Design' criterion has been ignored for this tool since IDE which is used together instead of Selenium WebDriver without interface will be effective. The code information requirement was specified in the test setup and operation criteria in the vehicle and it was emphasized that a few plugins were needed. As a result, the ease of use of the tool compared to other tools in the study was scored with a percentage (%).

Table 8. Usage evaluation for the Selenium WebDriver

Category	Evaluation Result
Installing and Running the Tool	Since it works integrated with other IDEs; compared to other tools in the study, it remains very laborious and challenging in terms of installation. (1p)
Interface Design	Since WebDriver does not have any interface, the interface of the IDE used should be considered. (2p)
Test Setup and Test Running	Test setup and execution are in the form of compiling the code by installing small plugins on the web browser. This requires code information. (1p)
General Result	4/10 points; Since the installation and running of the tool requires a certain amount of computer and programming knowledge, it is not easy to use except technical staff.

Table 9 presents the code information required to use the Selenium WebDriver tool and to run a test with this tool. The level of knowledge of the supported languages has been specified without elaborating and an evaluation has been made on the level of code to be used compared to other tools in the study. Compared to other tools in the study, it was observed that the code requirement is high and the result score was determined in the light of this information.

Table 9. Code requirement evaluation for Selenium WebDriver

Category	Evaluation Result
Supported Languages	It allows use in many languages. (3p)
Knowledge Requirement for Languages	The supported language must be known at least at the beginning-intermediate level. (1p)
Code Usage	Since the compilation of WebDriver by coding over IDE enables the test to be run, the code usage rate is much higher than other tools. (1p)
General Result	5/10 points; Although it supports many languages; Compared to other test automation tools in the study, the need for a lot of code requires code accumulation and experience from the end-user.

Table 10. Reporting evaluation for Selenium WebDriver

Category	Evaluation Result
Report Details	The code compilation results on the IDE that WebDriver presents as a report. (1p)
Report Readability	Reading the report requires programming knowledge since the report is the result of the compilation. (1p)
Report Content	It gives results in the form of technical error codes. (1p)
General Result	3/10 points; There is no detailed report that is easy to read. More time is needed to find out where the error is located.

Table 10 shows the evaluation of the reports of the Selenium WebDriver testing tool. Since Selenium WebDriver does not have an interface, the results on the IDE are based on the report details section. The readability of the report was also evaluated through the IDE. The submissions of the report are taken into account as the

report content of the IDE and finally, Selenium WebDriver gets a reporting score according to the user's opinion.

In Table 11, the pricing of the Selenium WebDriver tool has been evaluated. Seasonal fees were evaluated as user comments in this section. Price/performance analysis was evaluated by comparing the hardware performance on the devices for a periodic fee. The services included in the price are specified and as a result, the services and performance received are interpreted and scored.

Table 11. Pricing evaluation for Selenium WebDriver

Category	Evaluation Result
Monthly/Annual/Periodic Price	It provides completely free use. (4p)
Price/Performance Analysis	It is free and its performance is satisfactory; It makes Selenium preferable especially for medium-sized projects. (3p)
Services Include in the Price	Besides completely free usage, free documentation and free technical support are available. (3p)
General Result	10/10 points; Completely free usage, free services and supports, very good performance

Table 12 shows the technical support criteria of the Selenium WebDriver tool. It is stated which live support channels are used and the times when official support channels are available are added to the table in line with the information received from their web pages. In the community title, the extent to which platform users of the vehicle help and communicate with each other was evaluated by research. As a result, scoring was done by taking into account the official support channels, the hours of support, and the prevalence and helpfulness of the community.

Table 12. Support evaluation for Selenium WebDriver

Category	Evaluation Result
Support Channels	IRC provides live technical support via ChatRoom and Slack. (1p)
Support Times	A certain support hour is not promised. (2p)
Community	It has a very large community of users/developers so that support can be obtained outside of official channels. (3p)
General Result	6/10 points; The lack of precise technical support and the widespread of the community can make the user doubtful about the certainty and duration of the assistance to be received.

Table 13 presents how users of the Selenium WebDriver tool can access the documentation and training related to this tool. In the Tutorial Resource title, it was determined that the relevant tool does not officially offer a video tutorial. The Training Documents are officially available to everyone, and the availability of many Selenium WebDriver courses has been investigated worldwide independently. As a result, scoring was made by taking into consideration the ease of access to educational documents and document contents.

Table 13. Documentation and training evaluation for Selenium WebDriver

Category	Evaluation Result
Training Source	There is no official training channel. (1p)
Training Documents	Free training documents are shared publicly. (2p)
Courses	There are many certifications and training courses worldwide. (4p)
General Result	7/10 points; Access to educational resources is very easy.

Table 14 shows the DevOps and Agile support evaluation for Selenium WebDriver. Selenium test developers need to synchronize and orchestrate their test design and execution as per schedule and triggers, that are defined in their continuous integration or continuous delivery tools or platforms. Test Design needs to be more agile, effortless, and error-free. There is a shift towards the enhancement of existing or new test automation frameworks to integrate with continuous integration/continuous delivery pipelines seamlessly.

Table 14. DevOps/Agile planning support evaluation for Selenium WebDriver

Category	Evaluation Result
DevOps Support	There are many more tools such as Anthill, TeamCity, GitHub Actions, and similar platforms that are being used by testing and development teams. A Selenium testing framework needs to provide a mechanism for the tests to be triggered or can be called on-demand from these tools. (3p)
Agile Planning Support	Such tools, along with Kanban and Scrum boards in agile test management tools, enable us to achieve higher productivity among testing teams. (3p)
General Result	6/10 points; Although it is a great advantage to have many different tools and environments supported, the integration of Selenium with them can be challenging.

Table 15 shows the evaluation of the Katalon Studio tool from the perspective of the first user. The ease of loading the relevant tool to the devices (with reference to PC1 and PC2) is briefly stated in the installation and operation heading. While evaluating the interface design of the tool, it was taken into consideration whether it was tiring the user and compared with the interface design of other tools in the study. In the test setup and operation part, the Record and Playback feature was emphasized by considering how the interface affects these stages. As a result, the scoring was made by evaluating the simplicity of the interface and the speed/ease of installation.

Table 15. Usage evaluation for Katalon Studio

Category	Evaluation Result
Installing and Running the Tool	The installation of the software is extremely simple and effortless. (2p)
Interface Design	It has a simple interface that does not tire the user. (3p)
Test Setup and Test Running	Thanks to its simple interface and Record and Playback feature, the test is easy to set up, but it can deal with the user in situations such as determining the test requirements. (3p)
General Result	6/10 points; Its simple interface and quick installation provide great convenience.

In Table 16, the code information expected from the user was evaluated while using the Katalon Studio tool. The low number of languages supported was emphasized; however, these languages are also frequently preferred languages. It does not need any code, and it was evaluated by looking at the first user. It has been observed that it is possible to increase the quality of the test with the help of code, by emphasizing that it is possible for Katalon Studio to work without requiring a code. As a result, scoring was made considering the number of languages supported and the possibility of increasing the test quality.

Table 16. Code requirement evaluation for Katalon Studio

Category	Evaluation Result
Supported Languages	The number of supported languages is rather limited. (2p)
Knowledge Requirement for Languages	Although few languages are supported and code usage is low, the supported language needs to be known at a medium level. (2p)
Code Usage	With simple scripts, the test quality can be increased and the test scenario can be run without using any code. (2p)
General Result	6/10 points; The low number of languages supported may require extra information for intervention.

Test reports of the Katalon Studio tool are evaluated in Table 17. Adequacy of the details in the reports is interpreted; The necessary information for the readability of the reports is mentioned. The report's reports are simply stated, and as a result, the uncertainty of the report details is highlighted, compared to other tools in the study, it has been observed that reporting lags behind and scoring accordingly.

Table 17. Reporting evaluation for Katalon Studio

Category	Evaluation Result
Report Details	Report details sometimes do not have enough detail to find the solution to the problem. (2p)
Report Readability	Report readability requires basic knowledge of HTML or the technical content of the site. (1p)
Report Content	The report shows the acceptance/rejection status of each step. (3p)
General Result	6/10 points; Report details are not very clear and report legibility is difficult, leaving the tool behind in reporting.

In Table 18, an evaluation has been made regarding the pricing of the Katalon Studio tool. Seasonal fees were evaluated as user comments in this section. The table states that the use of the tool is free but conditional. As for performance, other tools in the study were observed to lag behind. It is stated that the fee covers only the support service and as a result, the condition and performance of the wage are taken into consideration while scoring.

The technical support criteria of the Katalon Studio tool are evaluated in Table 19. The existence of official support channels was mentioned and the times when these channels served were added to the table according to the data received from their website. Emphasis is placed on the inadequacy of the user community, and in the conclusion, Katalon Studio is insufficient in terms of technical support

compared to other tools in the study, and scoring is done accordingly.

Table 18. Pricing evaluation for Katalon Studio

Category	Evaluation Result
Monthly/Annual/Periodic Price	It provides completely free usage. A monthly fee must be paid for technical support. (3p)
Price/Performance Analysis	Although it is free, it makes it more tiring to test the devices compared to other tools, and it keeps the price in balance. (3p)
Services Include in the Price	24/7 technical support is provided for a fee for technical support. (2p)
General Result	8/10 points; It is free to use, but paid technical support reduces the result score.

Table 19. Support evaluation for Katalon Studio

Category	Evaluation Result
Support Channels	The official technical support channel is available. (3p)
Support Times	Official technical support is available 24/7. (4p)
Community	The lack of a large community makes support inadequate. (1p)
General Result	8/10 points; The fact that there are not many options other than official technical support and paid official technical support could be a problem.

Documentation and training possibilities of the Katalon Studio tool were evaluated in Table 20. On the official website, it has been observed that instructive resources and training documents are presented, and officially - in return for a fee - courses are offered. As a result, free training resources were taken into consideration, and scoring was made by concluding that these resources were sufficient especially for new users.

Table 20. Documentation and training evaluation for Katalon Studio

Category	Evaluation Result
Training Source	It is offered free of charge on the official website. (3p)
Training Documents	It is offered free of charge on the official website. (4p)
Courses	Officially provides training service. (3p)
General Result	10/10 points; Completely free training resources are quite sufficient for the use of the tool.

DevOps and Agile Planning support for Katalon Studio is evaluated in Table 21. For Agile Planning, Katalon Studio uses the support of Selenium which offers a comprehensive platform to perform automated testing for Web UI, API, desktop, and mobile. Hence, Katalon Studio uses the TestOps feature which is currently in beta version for analytics and DevOps support. Also, Katalon Studio supports Azure DevOps integration.

In Table 22, the convenience of installing the Telerik Test Studio tool regarding the devices in operation (PC1 and PC2) is mentioned and the simplicity of the interface design is emphasized. During the test setup and operation, the evaluation was made considering the simplicity of the

interface and as a result, scoring was made considering the easy setup compared to other tools in the study.

Table 21. DevOps/Agile planning support evaluation for Katalon Studio

Category	Evaluation Result
DevOps Support	Using own beta application (Katalon TestOps OnPremise (KTOP)) for which provides dynamic perspectives and an insightful look at automation testing data in a restricted network environment. (5p)
Agile Planning Support	It is using Selenium that means it supports agile planning as Selenium does. (2p)
General Result	7/10 points; Using its own application which is still in beta is a cons, but being built on Selenium is a good advantage for support.

Table 22. Usage evaluation for Telerik Test Studio

Category	Evaluation Result
Installing and Running the Tool	Its installation is extremely simple and fast. (2p)
Interface Design	Its simple interface provides ease of use. (4p)
Test Setup and Test Running	By creating scenarios in an extremely simple way, the tests are provided. (3p)
General Result	9/10 points; It offers easy installation and test preparation.

In Table 23, the code information required to use the Telerik Test Studio tool was evaluated. The evaluation was taken into consideration the popularity of the supported languages and it was observed that this use was for efficiency purposes. The user was found to be able to interfere with the code, and the scoring was not needed and the popularity of the supported languages was taken into account.

Table 23. Code requirement evaluation for Telerik Test Studio

Category	Evaluation Result
Supported Languages	It supports a limited number of popular languages. (2p)
Knowledge Requirement for Languages	Medium code knowledge is sufficient to increase efficiency. (3p)
Code Usage	Although code intervention can be made depending on the user's request, there is no need for code. (4p)
General Result	9/10 points; The lack of code and support for popular languages such as C# affects the tool's score positively.

The reports presented as a result of the tests run with the Telerik Test Studio tool are evaluated in Table 24. Report details in Telerik Test Studio are insufficient; however, it was observed that its readability is high. The richness of the presented reports in terms of visual content was evaluated positively and scoring was done accordingly.

In Table 25, an evaluation was made regarding the pricing of the Telerik Test Studio tool. Seasonal fees were evaluated as user comments in this section. In the table, the period and form of the pricing (user/device) are indicated. During the price/performance evaluation, it was concluded that the two criteria remained on average in this field as they gave different rankings when other applications in the

study were compared. Although only technical support in Price-Included Services affects scoring negatively, the main negative effect was the price being higher than other tools in the study and device-based pricing instead of the user. Scoring was done by considering all these.

Table 24. Reporting evaluation for Telerik Test Studio

Category	Evaluation Result
Report Details	The detail in the reports is very limited. (1p)
Report Readability	The readability is simple, as the reports are presented in non-technical sentences. (3p)
Report Content	It makes visual reporting with colorful graphics. (3p)
General Result	7/10 points; Report readability and presenting the report with graphics provide convenience to the user.

Table 25. Pricing evaluation for Telerik Test Studio

Category	Evaluation Result
Monthly/Annual/Periodic Price	Pricing is done on a single device annually. (2p)
Price/Performance Analysis	In terms of performance, although it outperforms other tools in the study, it lags behind other tools in pricing. (1p)
Services Include in the Price	Technical support is available for one year. (1p)
General Result	4/10 points; Pricing is higher than others and done on one device

The technical support criteria of the Telerik Test Studio tool are evaluated in Table 26. It has been stated that there are official support channels but these channels are included in the usage fee and the support times are very limited. The official forum which is active as a community and which can be called a high number of users has been examined. As a result, the limited time of technical support was evaluated as major negativity, and scoring was made.

Table 26. Support evaluation for Telerik Test Studio

Category	Evaluation Result
Support Channels	Official technical support is available. (2p)
Support Times	Support is provided during working hours throughout the year for a fee. (3p)
Community	The official forum is active and there are over two and a half million users in the forum. (3p)
General Result	8/10 points; The fact that official support has limited time despite paying wages leaves the tool behind other tools in support.

The training resources provided by the Telerik Test Studio tool are evaluated in Table 27. It was observed that the content of the free training offered officially was very detailed. At the same time, official training opportunities are offered for a fee. Considering all these, Telerik Test Studio is believed to be successful in documentation and training and scoring accordingly.

Table 27. Documentation and training evaluation for Telerik Test Studio

Category	Evaluation Result
Training Source	Educational videos are available on the official site. (3p)
Training Documents	Free training documents are offered. (3p)
Courses	Online training is given under various titles on the official site for a certain fee. (1p)
General Result	7/10 points; Detailed and free training, active forums, and various blog posts are offered free of charge.

In Table 28, DevOps and Agile support for Telerik Test Studio is evaluated. Telerik Test Studio provides to plug itself into Continuous Integration (CI) environment. It supports continuous integration and delivery by enabling testers to easily automate test cases and schedule those cases to run around the clock, without having to be physically present. Tests can be scheduled to run immediately after a build so that the team understands the state of the build immediately. The build can include the project to be tested, and once the build completes, tests can be set to run automatically. These features advance the support for DevOps and Agile Planning.

Table 28. DevOps/Agile planning support evaluation for Telerik Test Studio

Category	Evaluation Result
DevOps Support	It provides to plug itself into CI, so it can respond immediately to sudden interventions. (5p)
Agile Planning Support	Plugging into CI provides to help to use it in agile planning. (4p)
General Result	9/10 points; Instead of using integrations, plugging itself into CI is a good advantage

The usage experiences of Ranorex Studio are presented in Table 29. It was stated that the installation was simple and the interface was a little more complicated than the other tools in the study. However, since this mixed interface is similar to IDE interfaces, it is scored accordingly, considering that it will not tire users, especially with coding experience.

Table 29. Usage evaluation for Ranorex Studio

Category	Evaluation Result
Installing and Running the Tool	The installation of the software is extremely simple. (2p)
Interface Design	It has an interface that is not plain but resembles an IDE. (2p)
Test Setup and Test Running	The setup and conditioning of the tests can be achieved with a few simple commands. (4p)
General Result	8/10 points; It provides very easy use for users with programming experience.

In Table 30, the code information required for the effective use of the Ranorex Studio tool was evaluated. It has been observed that supported languages need some coding knowledge to support effective and detailed testing, and considering that they support popular languages; scoring was done by stating that detailed test results can be generated with code intervention.

Table 30. Code requirement evaluation for Ranorex Studio

Category	Evaluation Result
Supported Languages	It supports a limited number of popular languages. (2p)
Knowledge Requirement for Languages	Beginner-intermediate code knowledge is sufficient to write effective test cases. (3p)
Code Usage	Although it provides use without code; code may be required for fine and important details. (3p)
General Result	8/10 points; While supporting popular languages and providing uncoded use; To provide a detailed test scenario, code intervention is required.

The test reports submitted by Ranorex Studio are evaluated in Table 31. The details of the reports presented by the tool were found satisfactory and the reports were observed to be step by step. Although the interpretation of the test reports being categorized will vary according to the user, it was concluded that this situation prevented the report from being seen as a whole. Considering all these situations, the final scoring was done.

Table 31. Reporting evaluation for Ranorex Studio

Category	Evaluation Result
Report Details	The report presented at the end of the test run is detailed enough to show the reason for the errors. (4p)
Report Readability	Although the reports are categorized among themselves, it seems to facilitate readability, which makes it difficult to see the result. (2p)
Report Content	Results are shown, such as what action was performed at which stage. (3p)
General Result	9/10 points; In terms of readability, it does not provide convenience to the user to see the whole result.

In Table 32, an evaluation was made regarding the pricing of Ranorex Studio. Seasonal fees were evaluated as user comments in this section since the price table was given earlier in the study (Table 15). It is considered as a positive situation that the periodic fee is processed with a different system compared to other tools in the study. However, the usage fee requested for the first time was higher compared to the seasonal fees, and that there was only support and update in the service offered with the fee. Despite all this, considering the performance of the tool, the price/performance evaluation positively affected the scoring while scoring, since it offers a better result compared to other tools in the study.

The technical support criteria of Ranorex Studio are evaluated in Table 33. Although the technical support included in the price does not provide live support, it is experienced that a return is received within 24 hours via e-mail or form. The fact that the forums and blogs are active indicates that the audience is interacting. Scoring was done by considering these situations.

Table 32. Pricing evaluation for Ranorex Studio

Category	Evaluation Result
Monthly/Annual/Periodic Price	For single users, usage including updates and support is opened for a one-time fee, and annual renewal is done at lower pricing. (2p)
Price/Performance Analysis	Considering the performance it offers, it can prevent other automation tools in the study. (3p)
Services Include in the Price	Annual updates and support are provided for a one-time fee and continued use and extensible support for annual renewal. (2p)
General Result	7/10 points; Although the annual renewal fee is lower compared to other tools, there is a high level of one-time fee and inclusion of support in this fee.

Table 33. Support evaluation for Ranorex Studio

Category	Evaluation Result
Support Channels	The official support channel does not provide live support. (2p)
Support Times	Support is provided within 24 hours by e-mail or form. (2p)
Community	Active forums and blogs. (2p)
General Result	6/10 points; Lack of live support may cause delay of support.

Training channels of Ranorex Studio are evaluated in Table 34. It has been observed that various sources and documents are officially provided free of charge. In addition, it has been observed that the courses related to the tool are offered online through official channels. All this shows that Ranorex Studio is extremely successful in documentation and training.

Table 34. Documentation and training evaluation for Ranorex Studio

Category	Evaluation Result
Training Source	Official training videos are offered for free. (3p)
Training Documents	Official training documents and webinars are offered free of charge. (3p)
Courses	There are online courses on official channels. (3p)
General Result	9/10 points; All training documents are provided through official channels.

DevOps and Agile Planning support for Ranorex Studio is evaluated in Table 35. Ranorex Studio provides integration with Jira which is an issue tracking software by Atlassian and is used for agile project management, which includes test management. The Jira integration allows connecting Ranorex Studio solution to a Jira project. Then issues can be created manually for failed test cases directly from a test report or Ranorex Studio can automatically create and update issues on Jira. This feature advances the support for Agile Planning. To support DevOps, Ranorex also provides the connection with MS Azure DevOps which is a cloud-based continuous-integration software and provides all the necessary functionality for managing software development projects.

Table 35. DevOps/Agile planning evaluation for Ranorex Studio

Category	Evaluation Result
DevOps Support	MS Azure integration supports DevOps easily. (4p)
Agile Planning Support	Jira integration helps teams who work with Jira for tracking issues. (5p)
General Result	9/10 points; Having integrations depending on certain products can be challenging for those who do not use these products.

In Table 36, the evaluation of the use of the Squish tool with the eyes of the first user is given. It has been experienced that loading and starting the tool is not more difficult than other tools in the study. As an interface, Squish offers a design similar to IDE like Ranorex Studio, but it has a simpler interface that appeals to those with programming experience. Scoring was made considering that this situation would prolong the getting used to the process for users without programming experience.

Table 36. Usage evaluation for Squish

Category	Evaluation Result
Installing and Running the Tool	It provides a quick and simple installation. (2p)
Interface Design	It has an interface similar to a simple IDE interface. (2p)
Test Setup and Test Running	It provides test conditions in code compilation ease for users with programming experience. (2p)
General Result	6/10 points; Although it has a simple interface, the IDE-like interface may require familiarization for users without programming experience.

In Table 37, the code information required by the Squish tool for test conditioning was evaluated. The code information required to use and run a test with this tool has been evaluated. It has been concluded that during the test conditioning, continuous code in consideration and the need for at least a medium level of code information for instant interventions caused the tool to lag behind other tools in the study regarding the code requirement.

Table 37. Code requirement evaluation for Squish

Category	Evaluation Result
Supported Languages	It supports some script languages. (1p)
Knowledge Requirement for Languages	The supported language needs to be known at a moderate to a good level. (2p)
Code Usage	It requires the need to use code frequently and code information. (1p)
General Result	4/10 points; Although Record and Playback are necessary to have continuous codes in mind and to have sufficient code information for instant intervention.

Table 38 shows the evaluation of Squish's test result reports. Although Squish categorizes even the smallest results and presents them in color tables, it is positive in terms of detailed report analysis; It was concluded that the reports made it difficult to read. However, it has been

concluded that the report details and the step-by-step results of the reports may close this gap, albeit slightly.

Table 38. Reporting evaluation for Squish

Category	Evaluation Result
Report Details	The results of each scenario and each situation are categorized separately and presented to the user through colored tables. (4p)
Report Readability	It does not simply present the test result as a whole. (2p)
Report Content	It reports all steps individually, including scenario, status, and step counts. (3p)
General Result	9/10 points; Too much detail can cause negativity in terms of readability.

The pricing criteria for Squish are evaluated in Table 39. Since the performance it offers is lower than the other tools in the study, a negative effect was observed in the price/performance evaluation. It was investigated that the remuneration was not clear, and it was concluded that this was an extra cost for growing teams. Scoring was made considering the renewal fee is the same as the first fee.

Table 39. Pricing evaluation for Squish

Category	Evaluation Result
Monthly/Annual/Periodic Price	The price options, which start from a certain lower limit and vary according to the number of users in the team, are offered. (2p)
Price/Performance Analysis	Considering the performance and pricing it offers, it lags behind other tools evaluated in the study. (1p)
Services Include in the Price	Included in the price is support and update support for a year. (2p)
General Result	5/10 points; The fact that the renewal fee is the same as the first price increases the cost for growing teams.

The support criteria of Squish are evaluated in Table 40. It was observed that there was no live support and no clear support time was specified. It has been seen that support can be obtained via form or e-mail through official channels, and the community has been informed that it organizes various activities. Scoring was done considering the absence of live support, not a promising time for the support and organizing various activities.

Table 40. Support evaluation for Squish

Category	Evaluation Result
Support Channels	Support can be obtained through form or e-mail in official channels. (2p)
Support Times	Since there is no live support line, no clear support time is specified. (2p)
Community	The software distributor has a forum for the company. Besides, various events are organized at various times. (2p)
General Result	6/10 points; No live support is provided, and the support channels are more effortless to reach than the support channels of other tools.

The training offered by the Squish tool is evaluated in Table 41. It has been seen that educational materials in various formats are officially presented. It has been observed that free training documents are officially presented; it has been observed that training and consultancy services are provided under the leadership of

experienced staff. As a result, various activities were scored by participating in the evaluation.

Table 41. Documentation and training evaluation for Squish

Category	Evaluation Result
Training Source	Educational materials are available in screencast and webinar formats. (2p)
Training Documents	Free educational documents are provided through official channels. (3p)
Courses	Short-term training and consultancy services are provided under the leadership of experienced staff. (3p)
General Result	8/10 points; Free training documents are offered and events are organized.

In Table 42 DevOps and Agile support for Squish is evaluated. Jira integrates with Squish Test Center which is a test result management system that can store the history of the test results for the analysis of trends and platform-specific factors, to automate the pushing of test results from Test Center to Jira and allows for mapping of Jira issues to Squish test cases. This provides support for Agile Planning. Test Center is integration for Squish and it is provided by the same company as Squish, froglogic. Automated GUI tests developed with the Squish GUI Tester can be easily executed with Azure DevOps on Azure Virtual Machines. As conclusion, Squish provides DevOps support via MS Azure.

Table 42. DevOps/Agile planning support evaluation for Squish

Category	Evaluation Result
DevOps Support	MS Azure integration supports DevOps easily, but Virtual Machine should provide some kind of display (e.g., by the active RDP connection). (3p)
Agile Planning Support	Jira integration provides automated pulling/pushing and automated bug reporting. (5p)
General Result	8/10 points; Using other integrations for integration is not a big deal but it is challenging.

The usage assessment of the TestingWhiz tool is given in Table 43. The installation of the tool is simple and its interface is similar to IDE. Since the test setup and operation is similar to creating a software project from scratch, it is concluded that it is a difficult and difficult test setup to get used to and scoring accordingly.

Table 43. Usage evaluation for TestingWhiz

Category	Evaluation Result
Installing and Running the Tool	Installation is simple. (2p)
Interface Design	The interface design resembles the IDE interface. (2p)
Test Setup and Test Running	The installation phase is similar to creating a software project from scratch. Therefore, it can take time to get used to it. (2p)
General Result	6/10 points; The test setup is not easy.

Code requirements of TestingWhiz are evaluated in Table 44. It has been observed that when the tool is used, it meets the 'less code' status, which is their purpose. With almost no need for code, it has been experienced that the user is

aimed to focus on test scenarios and scoring is done by considering this situation positively.

Table 44. Code Requirement evaluation for TestingWhiz

Category	Evaluation Result
Supported Languages	It supports a very limited number of languages. (1p)
Knowledge Requirement for Languages	It is sufficient to know it at the beginner level. (3p)
Code Usage	Code usage is rarely needed. (3p)
General Result	7/10 points; The need for code is reduced to a minimum, and the user is intended to focus on test cases rather than code.

The reports submitted by the TestingWhiz test tool are evaluated in Table 45. It has been observed that TestingWhiz does not go into detail in the reports and it needs programming experience to read the reports it offers effectively. Assuming that this situation will waste time in error solutions, it has been evaluated. TestingWhiz's step-by-step actions during test conditioning were seen as a positive result, and scoring was done accordingly.

Table 45. Reporting evaluation for TestingWhiz

Category	Evaluation Result
Report Details	The superficial report is presented without going into details. (3p)
Report Readability	Report readability, programming experience is required. (1p)
Report Content	The actions during the test run are indicated step by step. (2p)
General Result	6/10 points; The report is superficial and, however, the readability of the report is poor; it may take time to solve some errors.

In Table 46, the price/performance evaluation of the TestingWhiz test tool was intended, but it was emphasized that such an evaluation is not possible in the current situations.

Table 46. Pricing evaluation for TestingWhiz

Category	Evaluation Result
Monthly/Annual/Periodic Price	Offers are presented according to the project budget, project duration, and size of the company. Therefore, no pricing assessment has been made for TestingWhiz during the study process. (1p)
Price/Performance Analysis	
Services Include in the Price	
General Result	1/10 points; Lack of a clear price tag can make it difficult for the user to decide.

The technical support criteria of the TestingWhiz tool are evaluated in Table 47. Unlike other tools in the study, TestingWhiz has been observed to offer telephone support, and this situation is foreseen to provide convenience in emergency support needs. As a community, having a weaker community than other tools in the study has been observed to affect the activity status of the forums. Scoring was done by seeing that support can be obtained through e-mail and form channels on official channels besides the telephone.

Table 47. Support evaluation for TestingWhiz

Category	Evaluation Result
Support Channels	Support is provided by phone, e-mail, and form on official channels. (3p)
Support Times	Telephone support can provide convenience in emergencies. (4p)
Community	It does not have an active and dense forum. (1p)
General Result	8/10 points; The lack of a large and active community forces the user to official technical support.

The training materials provided by TestingWhiz are evaluated in Table 48. It has been observed that there are educational videos in the official channels in the form of summaries and written materials are presented as a summary without going into detail. The collection of tool training materials under a single text is envisaged as restricting the access of the user to the desired training. Scoring was made by observing that various visual education materials were presented apart from the text.

Table 48. Documentation and training evaluation for TestingWhiz

Category	Evaluation Result
Training Source	There are short and summary training videos. (3p)
Training Documents	Although it is not in the form of a document, summary information about the tool is presented under a single text. Apart from this, there are various infographics, sample videos, and webinars. (3p)
Courses	Educational materials are provided through the webinar. (2p)
General Result	8/10 points; Educational materials are inadequate compared to other tools.

DevOps and Agile Planning support for TestingWhiz is evaluated in Table 49. TestingWhiz has an integrated mobile recorder which allows user to automate test recording on multiple mobile applications/devices. Users can also record and run the same test cases on multiple devices. The tool also has SVN Integration which collaborative software development is an approach that allows multiple teammates to share work. TestingWhiz allows executing test scripts on the server via TestingWhiz CI plugins such as Jenkins or Bamboo. This provides validating the application on regression cycles and provide reports to CI tools on a continuous basis. It also has an integrated Python editor to create a new python script or import an existing script.

Table 49. DevOps/Agile planning support evaluation for TestingWhiz

Category	Evaluation Result
DevOps Support	Allows easy implementation of many integrations that support DevOps. (5p)
Agile Planning Support	Some integrations, such as SVN, provide agile planning. (3p)
General Result	8/10 points; It is a great advantage to have many integrations and not be tied to a specific platform or product.

The usage evaluation in Table 50 shows the summary of the evaluation results given between Tables 8 and 49. In this general evaluation, the relevant test automation tool was evaluated from the ground up assuming its use. Also, while scoring, the process of contacting the relevant companies for the full version of the tools was not taken into account.

Table 50. Average evaluation of the test automation tools

Test Automation Tool	A	B	C	D	E	F	G	Total
Selenium WebDriver	4	5	3	10	6	7	6	41/70
Katalon Studio	6	6	6	8	8	10	7	51/70
Telerik Test Studio	9	9	7	4	8	7	9	53/70
Ranorex Studio	8	8	9	7	6	9	9	56/70
Squish	6	4	9	5	6	8	8	46/70
TestingWhiz	6	7	6	1	8	8	8	44/70

A: Ease of Use
B: Code Requirement
C: Reporting
D: Pricing
E: Support
F: Documentation and Education
G: DevOps/Agile Planning Support

In this context, the ratings between 1-70 were made with the following distribution:

- Ease of Use (Interface Simplicity) (1-10; 1 is very difficult, 10 is very easy)
- Code Requirements (1-10; 1 maximum need, 10 minimum need)
- Reporting (1-10; 1 difficult to understand, 10 easy to understand)
- Pricing (1-10; 1 high, 10 low)
- Support (1-10; 1 hard to reach, 10 easy to reach)
- Documentation and Training (Between 1-10; 1 difficult to access, 10 easy to access)
- DevOps/Agile Planning Support (Between 1-10; 1 limited support, 10 advantageous support)

According to the scoring results given in Table 50, Ranorex Studio has received the highest score and this can be considered as an indication that the Ranorex tool is has more advantages over other examined test tools. Of course, this result may vary depending on the device, the websites used, the test scenario followed, and even the way companies follow their current price and support policies. However, it is anticipated that such a study will give an idea to the people who will work in this field.

5. CONCLUSIONS

As observed in the final and average evaluation, test automation tools are capable of automating almost the entire testing process. Of course, there will be situations that require manual interventions.

Automating important tests will give better results with more feedback. Automation of tests can reduce the workload of the test engineer, improve software quality, and shorten test time. There are many benefits to using Automated Software Testing, but achieving this is not an easy task. Especially when developing websites, the testing process is not taken into account as it should be, and the maintenance is done according to the feedback of the user. This situation affects both the developer and the user negatively.

The question of which test tool, for what reason to choose, in the requirement analysis phase, which is the basis of the test process and significantly affects the progress stages of the process and is the first step, can lead to time loss.

Trying to select the appropriate tool by applying each tool individually means extra time and effort. This will cause a direct disruption of the direct testing process and indirectly, the software development process, especially in terms of time. Entering such a risk of time and cost loss in the software development process, where time and cost are critical, will cause problems in proportion to the size of the project and perhaps a decrease in the motivation of the staff in the project.

This paper presented an evaluation and analysis of different test automation tools used to test websites according to several criteria such as (i) performance, (ii) cost, (iii) usability, (iv) code requirement, etc. We believe that this study will be a useful guide for reducing testing costs and time in developing websites.

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