THE QUALITY ASSESSMENT OF SOFTWARE TESTING PROCEDURE AND ITS EFFECTS

Najia Saher[1], Dost Muhammad Khan[2], Faisal Shahzad[3], Ayesha Karim[4]
[1,2,3] Department of Computer Science & IT, The Islamia University of Bahawalpur, Pakistan
E-mail: {najiasaher, faisalsd}@gmail.com**,** khan.dostkhan@iub.edu.pk
[4] National University of Computer and Emerging Sciences, Lahore, Pakistan, ashmeer@gmail.com

ABSTRACT- *It is very competitive for software companies to develop the higher quality software utilizing a negligible besides strictly observing the timelines as well. Testing the software for accuracy and functionality is generally the final stage in the SDLC process before releasing software. This paper portrays the findings of our research-based study that has two fold primary targets. At the point when ought to a test be automated and when it ought to be manual. 2).The trade-off between Manual software testing and automated software testing. Furthermore, we have investigated the current framework's testing technique thoroughly on the basis of cost, time and number of errors detected during the functional, security, and performance testing using manual and automated test approach.*

Keyword— Automation Testing, Manual Testing, Defects, Functional testing, Security testing, Performance Testing

1. INTRODUCTION

Testing is a standard procedure used to authenticate that product complies with its formal requirements. The principle goal of testing incorporates the certification of the product quality by discovering and removing with its shortcomings, exhibiting the vicinity of its all predefined usefulness and assessing the operational dependability of the software product. The testing process incorporates all the exercises used to figure out the contrasts between requirement of the product and its actual conduct.

Testing can be categorized as manual and automated, however both methodologies are correlated. In case of automated testing the script is composed by tester and programming is used to test the product while during manual testing the tester physically implement the test cases without the aid of any automated tool. Manual testing is considered as the embryonic sort of all testing categories that help to discover bugs in product framework. Automated testing is capable of performing a large number of tests in brief time, though manual testing uses the information of the testing specialist to target testing to the parts of the system that are certain to be more mistake inclined.

Automated test instruments are capable guides to enhance the return on the testing asset when utilized carefully. A few tests naturally oblige an automated way to be operative, however others must be manual. Moreover, automated testing projects that fail have a large impact on project in term of expense. In what manner would we be able to perceive whether automate a test or run it manually, and what amount of cash and time would it be advisable for us to use on a test?

Our point is to fortify discourse about functional and non-functional testing methodology utilizing manual or programmed test era. A few tests are suitable for automated testing method because it is a fact that some specific types of tests aren't possible manually in any significant way. Different tests, on the other hand, are either best when done manual or just done physically. Similarly with test methodologies, decision of the suitable choice in this context will have a veritable impact on the return on investment.

In this research paper we will answer the issues such that, which is the best testing methodology manual or automated in term of performance, functionality and security of web based applications and an exchange of automated and manual testing. Here we would take the three attributes that would effect on above stated technique i.e. cost, time and number of errors detected manually or automated software testing approach. We additionally compare the effect of applying these testing procedures and its resulting effect on performance, functionality and security.

Whatever remains of the paper is sorted out as takes after: Section 2 is about the Testing Procedure of Software Quality, Section 3 is about Literature Review, Section 4 is Methodology, Results are discussed in Section 5 and finally Conclusion is drawn in Section 6.

2. Testing Procedure of Software Quality

Testing is the standard procedure used to approve that product fits in with the formal requirements. The principle objectives of testing fuse avowing the product quality by finding and administering errors in the project, showing the vicinity of all predefined usefulness in the software and assessing the operational quality of t

he product. Software testing includes all the exercises went for recognizing the contrasts between specification details of the software product and the real conduct. The activities like planning, design, implementation, execution and evaluation makes up together the testing process. A general testing process is depicted in Figure 1

For an application testing both the manual and automated testing methods are quite unlike systems. The manual testing is a straightforward process as contrast with automated method, manual testing is time consuming and it is conceivable up to certain level however in automated process each sort of testing is conceivable utilizing distinctive sorts of tools. In contrast to manual testing, the automated one is more costly. Generally small scale project is utilized by manual testing in light of the fact that it is effective and conceal in constrained course of time. Manual testing is centered around idea, functions of the project however the automated tools backings to restricted dialects.

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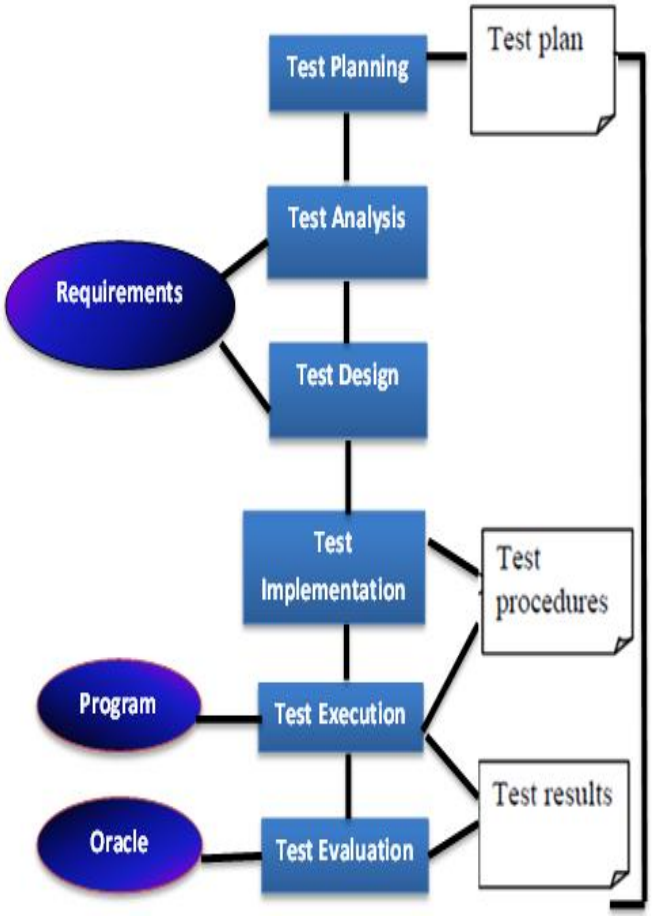

Figure 1 – The general testing process

Capers Jones, "In Estimating Software Costs, cites failure rates for large, complex system development efforts as high as 50%—or higher. A test automation project can be just as complex as developing software, and, indeed, Dorothy Graham and Mark Fewster cite similar failure rates for automation projects in Software Test Automation".

2.1 Manual Testing:

In this technique the software product is tested manually using test cases. The test designer does all the experiments (test cases) and executes on the application manually and shows whether a specific step was fulfilled effectively or whether it failed. For manual testing the information needed by the tester are only the test case and the guideline about how to execute that case.

As per tactics of a test plan a test case must comprise of all sorts of testing. Design document is used as a source to write a test case by a test engineer. Manual testing is dependably a piece of any testing exertion. It is essentially profitable pilot stage of software development phase, when the software and its user interface are not sufficiently steady, and starting the automation does not bode well. The manual testing process is depicted in figure 2. [9]

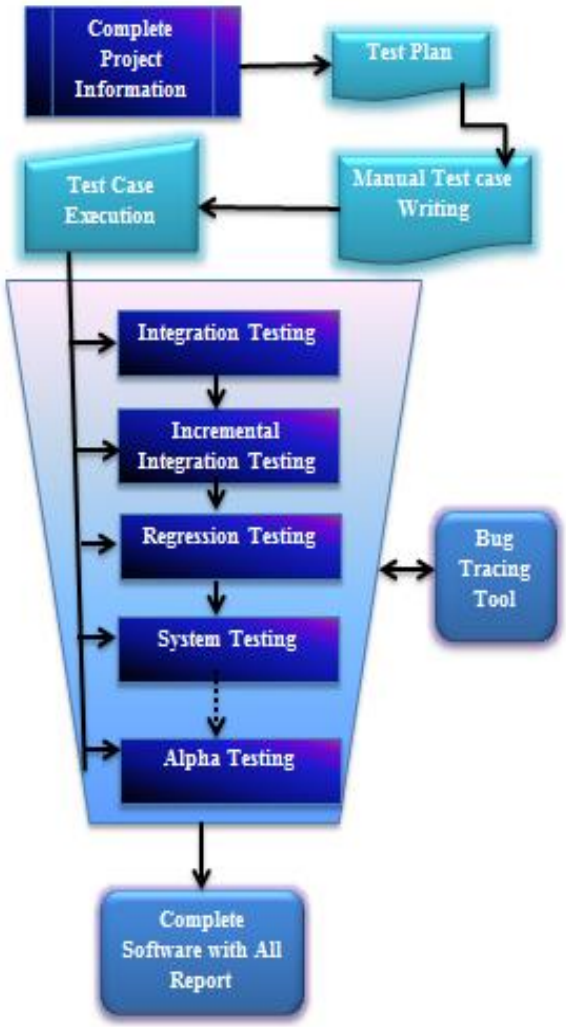

Figure 2 – The manual testing process

2.2 Automation Testing:

In automated testing methodology, test engineers run the script on any testing instrument for evaluation and testingpurpose. To test software utilizing script in automated tool is a difficult job for a new test engineer, as the engineer ought to have decent programming information first and afterwards they can compose a script against any test case.Here these individuals take after the plan and make numerous scripts for several testing. To change over a test case into script is an absolutely time consuming job. Before they run a script, we need to set an environment on tool to run the test case, as the test script are essential in light of the

fact that, a solitary change might become a reason of the failure of whole script. At the stage of script execution the frame ought to have the same as all the scripts are considered vital aim GUI object of the screen and are main information while writing a test script. [9].The automated testing process [9] is depicted in figure 3.

The major benefits and drawbacks of a manual testing vs Automation [16] testing are depicted in Table 1.

3. Literature Review

In [25] accurate estimates of the return on investment of test automation entail the analysis of costs and benefits involved. However, since the benefits of test automation are particularly hard to quantify, many estimates conducted in industrial projects are limited to considerations of cost only. In [7], a case study originally published by Linz and Daigl, "[18] is presented, which details the costs for test automation as follows:

V: = Expenditure for test specification and implementation

D: = Expenditure for single test execution"

Accordingly, the costs for a single automated test (*Aa*) can be calculated as eq. (1):

$$Aa: = Va + n * Da \quad (1)$$

As describe in [25] "where *Va* is the expenditure for specifying and automating the test case, *Da* is the expenditure for executing the test case one time, and *n* is the number of automated test executions. Following this model, in order to calculate the break-even point for test automation, the cost for manual test execution of a single test case (*Am*) is calculated similarly as eq. (2)".

$$Am: = Vm + n * Dm \quad (2)$$

"Where *Vm* is the expenditure for specifying the test case, *Dm* is the expenditure for executing the test case and *n* is the number of manual test executions". Figure 4 depicts these relations.

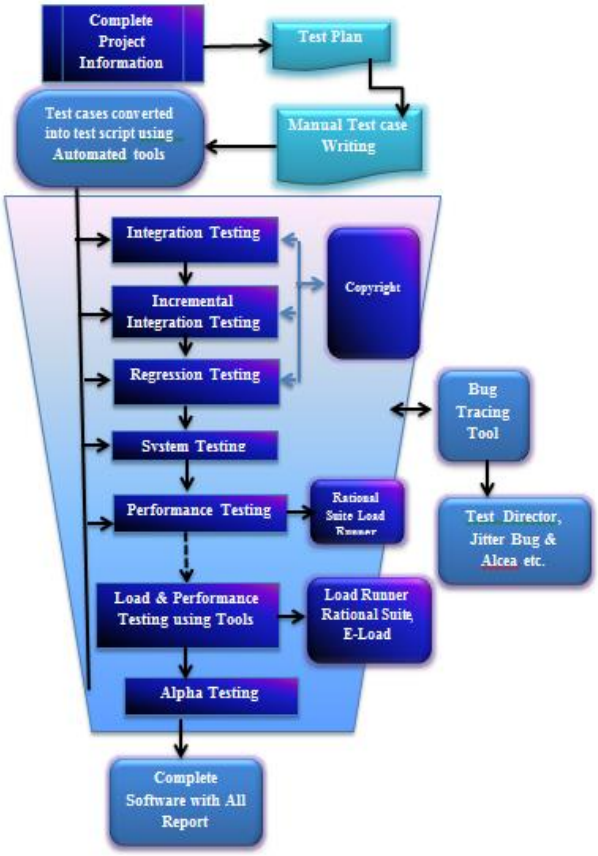

Figure 3 – The automated testing process

Table 1: Benefit and Challenges of a manual testing vs Automation testing

Benefit of Manual and Automation Testing	
Benefits of a Manual Testing	**Benefits of an Automated Testing**
Manual testing can be used in both small and big project	***Fast:*** Cover up all cases in a limited time period.
Easily we reduce and added our test case according to project movement.	***Reliable:*** Automated testing tools, run the scripts reliably each time. Exact same steps are followed every time, the script is run.
It is covered in limited cost.	***Comprehensive:*** One can build a suite of tests that covers every feature of application. It is always desirable to test the complete functionality of the software.
Easy to learn for new people who are entered in manual testing.	***Reusable:*** One can reuse tests on different versions of a website or application, even if the user-interface changes.
Manual is more reliable then automated (in many cases automated not cover all cases)	**Time Constraints:** Auto testing is good for those projects, which have no time constraints.
Challenges of Manual and Automation Testing	
Challenges of Manual Testing	**Challenges of Automation Testing**
GUI objects size difference and color combination etc.	Automation testing is expensive as compare to manual testing.
Actual load and performance is not possible to cover	Selection and customization of Test Tool
Running test manually is very time consuming job.	Selection of Automation Level than development and verification of script.

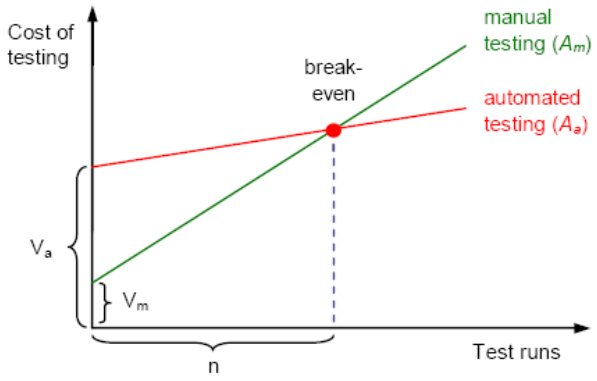

Figure 4: Manual and Automated Testing Cost

Figure. 4 shows a relation between manual and automated testing. The x-axis represents the number of test runs, while the y-axis represents the cost of testing. The figure depict how the costs increase with every test run. While the curve for manual testing costs is sharply rising, automated test execution costs increase only moderately. But, automated testing needs a higher initial investment as compare to manual test.

Bach [22] argues that "hand testing and automated testing are really two different processes, rather than two different ways to execute the same process. Their dynamics are different, and the bugs they tend to reveal are different. Therefore, direct comparison of them in terms of dollar cost or number of bugs found is meaningless."

Boehm criticizes this on value-based software engineering [23]: "Much of current software engineering practice and research is done in a value-neutral setting, in which every requirement, use case, object, test case, and defect is equally important. In a real-world project, however, different test cases and different test executions have different priorities based on their probability to detect a defect and on the impact which a potential defect has on the system under test".

Johnson Michael [2] discusses the performance-testing approach required manually inspecting the performance logs. Another direction of future work is automatic performance test generation. In this project, we relied on the performance architect's experience to identify the execution paths and measurement points for performance testing. We can derive this crucial information for performance testing from the performance requirements and system design. We plan to find guidelines for specifications of performance requirements and system design to make the automation possible.

Andreas Leaner [7] discusses the "strength of automatically generated and manually written test and conclude that both have different strengths. An automatic strategy can generate and run a much greater number of test cases than a human could run in the same time".

Rudolf Ramler in [8] discussed "cost models to support decision making in the trade-off between automated and manual testing. He summarized typical problems and shortcomings of overly simplistic cost models for automated testing frequently found in literature and commonly applied in practice: only costs are evaluated and benefits are ignored, incomparable aspects of manual testing and automated testing are compared, all test cases and test executions are considered equally important, project context, especially the available budget for testing, is not taken into account and additional cost factors are missing in the analysis. He also introduced an alternative model using opportunity cost. The concept of opportunity cost allows us to include the benefit and, thus, to make the analysis more rational". In [27,28] different methods are used to select the best data mining algorithm for a dataset.

4. METHODOLOGY

For this case study we have collected data from Insurance domain consisting 4 projects having 31 releases. In order to address the problem, we will use statistical analysis to find whether manual testing or auto testing is best for web base projects. The questioner prepared will try to identify successful and challenging areas in the existing approaches used during the testing of web-based systems. By analyzing this data; we will be able to find the best testing technique.

We have investigated the existing system's testing technique thoroughly on the basis of cost, time and number of errors detected during the functional, security, and performance testing using manual and automated test approach. We collected data against the above mentioned measures and have analyzed the collected data through statistical techniques.

Following table presents data statistics that we have collected using a questionnaire.

Table 2: Data collection statistics

Attribute	Value
Data Collection	Questionnaire
Sample Size	4 Projects
Project Type	Web-based software applications
Project Duration	4 to 6 Months (Release)

T-test analysis technique has been conducted in the data analysis. SPSS statistical package is used to apply T-test technique.

4.1 Hypotheses and Research Site

The background of this study is about automated and manual testing. When should a test be automated and when it should be manual and the trade-off between Manual software testing and Automated software testing.

For this we compare automated and manual testing on the parameter of '*cost'*, '*time'* and '*number of error identified'*.

Table 3: Data collected from organization

Organization Detail	
Organization size	800 employees
Organization's Maturity level	CMMI Level 5 ISO Certified
Project Details	
Number of project under study	**Four** Project A = 3 Releases Project B = 14 Releases Project C = 6 Releases Project D = 8 Releases
Domain of the project under study	Insurance
Average duration of each release in a project	Project A = 120 days Project B = 110 days Project C = 180 days Project D = 90 days
Average number of resource utilized in each release of a project	**Project A:** Team size: 15, Quality Assurance = 4 testers **Project B:** Team size: 20, Quality Assurance = 4 testers **Project C:** Team size: 40, Quality Assurance = 5 testers **Project D:** Team size: 10, Quality Assurance = 5 testers
Technology used in the selected projects	Project A Dot Net Project B Dot Net Project C Dot Net Project D Dot Net

We consider '*Cost'* on the basis of, licensed cost, man hours, training cost and maintainability cost.

Time on the basis of testing time and training time. *Number of error identified* during (Functional testing, Performance testing and security testing)[1] we also consider usability testing but during collection of data in a software house we didn't find any data regarding automated testing of usability.

Hypothesis I

The purpose of this hypothesis is to test the cost of the *Manual 'Testing'* and *Automation testing*. Here the variable testing has two categories, automation and manual whereas the variable *'Cost'* has four categories: l*icensed cost, man hours, training cost and maintainability cost*. To prove the hypothesis, we have used regression analysis and applied the T- Test.

Null Hypothesis:

$H_{0:}$ Automation cost (*licensed cost, salary, training cost, maintainability cost*) is greater or equal to manual cost (*licensed cost, salary, training cost, maintainability cost*).

Alternate Hypothesis:

$H_{1:}$ Automation Cost (*licensed cost, salary, training cost, maintainability cost*) is less than Manual Cost (*licensed cost, salary, training cost, maintainability cost*)

Hypothesis II

The purpose of this hypothesis is to test the 'Time' taken by the Manual testing and Automation testing. Here the variable testing has two categories, Automation and Manual whereas the variable *'Time'* has two categories, *Testing Time and Training Time*. To prove the hypothesis, we have used regression analysis and applied the T- Test.

Null Hypothesis:

$H_{0:}$ Automation Testing Time (*Testing Time, Training Time*) is greater or equal to Manual Testing Time (*Testing Time, Training Time*).

Alternate Hypothesis:

$H_{1:}$ Automation Testing Time (Testing Time, Training Time) is less than Manual testing Time (Testing Time, Training Time).

Hypothesis III

The purpose of this hypothesis is to test the "Number of Errors Identified/count" of the Manual testing and Automation testing. Here the variable testing has two categories, automation and manual whereas the variable 'Errors Identified' has three categories: Functional, Security and Performance. To prove the hypothesis, we have used regression analysis and applied the T- Test.

Null Hypothesis:

$H_{0:}$ Automation Testing Errors Identified (In *Functional testing, Security testing, Performance testing*) is greater or equal to Manual Errors Identified (In *Functional testing, Security testing, Performance testing*).

[1] We collect data on following parameter
(Functional testing has been checked on the basis of User requirement-SRS.
System security on the basis of Authentications and password checking.
Performance testing on the basis of Load testing and stress testing)

Alternate Hypothesis:

H_1: Automation Testing Errors Identified (In *Functional testing, Security testing, Performance testing*) is less than Manual Errors Identified (In *Functional testing, Security testing, Performance testing*).

4.2 Research Site and Data Collection

For this research a leading software organization has been chosen with diverse commercial applications having more than 800 employees and at CMMI level 5 for our research site. In Table-3, there is a detail of the organization and its projects. All the projects belong to the e-Commerce domain having four projects with 30 releases.

Table-4: T-Test results of Cost at significant level of 0.05

Group Statistics

	Testing	N	Mean	Std. Deviation	Std. Error Mean
Cost	Auto	31	3193.4839	1151.68879	206.84941
	Manual	31	3956.8065	2293.26628	411.88278

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Cost	Equal variances assumed	11.937	.001	-1.656	60	.103	-763.32258	460.90575	-1685.27134	158.62618
	Equal variances not assumed			-1.656	44.228	.105	-763.32258	460.90575	-1692.08211	165.43694

5. RESULTS AND DISCUSSION

In this section we will discuss our findings based on the Statistical analysis of the hypotheses[2].

5.1 Hypothesis-I: Relationship b/w Automation and Manual Testing in term of Cost.

For hypothesis-I we have combined all the releases of the four projects to determine if there is a relationship between the automated and manual testing with respect to cost. Our results in Table-4 indicate that there is a significant relationship between automated and manual testing since the p value 0.103 of T-Test is greater than 0.05 so we are failed to reject Null hypothesis. It shows that Automation cost is greater than the Manual cost Figure 5 and Table-4 present the Automation testing cost is higher than manual testing cost if we include all the licensing and training cost. Especially the factor; licensing of automation tool mainly maximizes the testing cost.

This is the reason; Figure -6 is showing the cost of automation and manual with respect to Project A and its releases. Here if we add all tool costs in first project Release and other yearly licensing cost then automation cost in Release 2 and Release 3 comes out to be less than the manual cost.

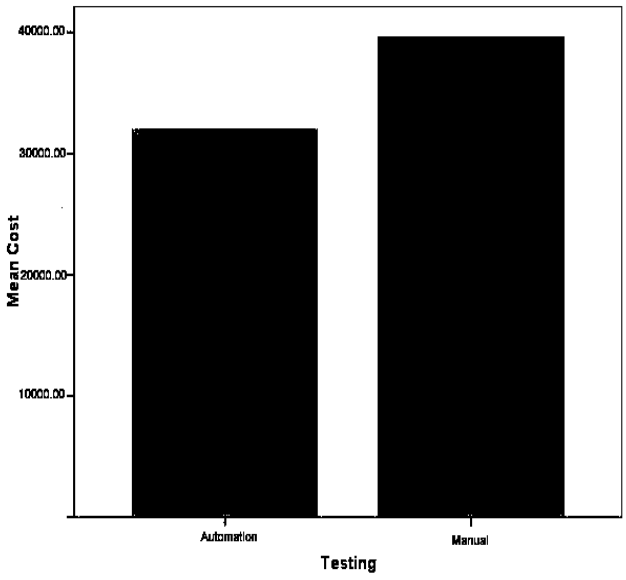

Figure 5- Cost of four projects not including α –cost

[2] (Mathematical Description of the hypotheses is given in the Appendix)

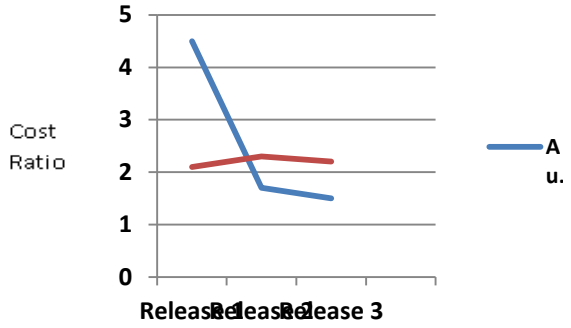

Figure 6- Automation Cost vs Manual Cost in Project A

The total Cost[3] of testing is defined as the sum between the cost of manual tests and the cost of automated tests:

$$C_T = C_L + C_M + C_S + C_{TR}$$

Table-5: Testing Cost

Testing Cost per Single Release	
Licensing Cost	Rs. 9,96,000/-
Maintainability Cost	18%
1year Maintainability cost:	Rs. 1,79,280/-
3years Maintainability cost:	1,79,280 *3 = Rs. 5,37,840/-
Total Three years cost	Rs. 15,33,840/-
Overall Project Done	14
One project test cost	1,09,560
Training Cost	
Training Time	1 month
Avg. Salary	Rs. 30,000/-
Salary/hr.	Rs. 170/-
Training Cost	Rs 30,000/-

Testing Cost per Single Release = *Testing time-in-hr. * Salary / hr. + Avg Training cost + Avg (α) Licensing Cost + Avg Maintainability cost*

If we do not take this alpha cost for these projects then the automation cost is less than the manual cost based on working hours and salary according to those working hours.

Table-6: Sample data of Project A that shows the Number of releases of project A, Error Identify, time and cost

Area	Releases	Area	No of Scripts	No of Error	Time	Cost
Automation	R1	Functional	72	10	25	4250
		Performance	3	2	1	170
		Security	5	2	2	340
	R2	Functional	76	6	16	2720
		Performance	4	3	1.5	255
		Security	5	2	2.5	425
	R3	Functional	91	9	20	3400
		Performance	11	3	2	340
		Security	5	1	1	170
Manual	R1	Functional	78	12	28	4760
		Performance	7	1	4	680
		Security	5	2	7	1190
	R2	Functional	76	6	42	7140
		Performance	4	2	4	680
		Security	5	2	4	680
	R3	Functional	91	9	47	7990
		Performance	15	3	8	1360
		Security	5	1	4	680

Figure 7 and Table-7 present the Automation testing saves the time during regression testing, performance testing, load testing, and stress testing because the script in Auto test is written once but in manual testing one has to start from the scratch. We also concluded that it is very hard to do regression testing manually, especially in released project. Automation testing is performed swiftly and therefore saves time of testers. Fig-6 is showing data of testing time and manual time in working days. By combining all project data it is finally concluded that automation testing almost saves half of the manual testing time.

5.3 Hypothesis-III: Relationship b/w Automation and Manual Testing in term of Number of Defects Identified.

For hypothesis-III, Table- 8 indicates the relationship between Defects Identified by manual or automated testing, since the p value of T-Test 0.657 is greater than 0.05. So we are failed to reject Null hypothesis. It shows that number of defects identified in Automation testing is greater than the manual testing.

Table-8 and Table-9 present that automation testing generates the best result in functional, performance and security testing. As performance testing include load, stress testing is easily identified in automation testing.

In Fig-8 mean number of defects are identified in all 4 projects combining all releases. Here the data is collected on the basis of functional, performance and security test cases. However, there is a slight difference between automation and manual as far as performance and security are concerned because in manual it is complicated to attempt all scripts and all possible combinations while automation executes all possible combinations just by writing a single script.

[3] C_T: Total Cost, C_L: License Cost, C_M: Maintainability Cost, C_S: Salary Cost, C_{TR}: Training Cost

Table-7: T-Test results of Time at significant level of 0.05

Group Statistics

	Testing	N	Mean	Std. Deviation	Std. Error Mean
Time	Auto	31	17.9677	6.64572	1.19361
	Manual	31	30.3548	17.82610	3.20166

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Time	Equal variances assumed	12.832	.001	-3.625	60	.001	-12.38710	3.41692	-19.22195	-5.55224
	Equal variances not assumed			-3.625	38.181	.001	-12.38710	3.41692	-19.30321	-5.47098

Table-8: T-Test results of Error Identified at significant level of 0.05

Group Statistics

	Testing	N	Mean	Std. Deviation	Std. Error Mean
ErrorIdentified	Auto	31	8.0323	6.16703	1.10763
	Manual	31	7.3871	5.18766	.93173

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
ErrorIdentified	Equal variances assumed	1.721	.195	.446	60	.657	.64516	1.44740	-2.25007	3.54039
	Equal variances not assumed			.446	58.291	.657	.64516	1.44740	-2.25182	3.54214

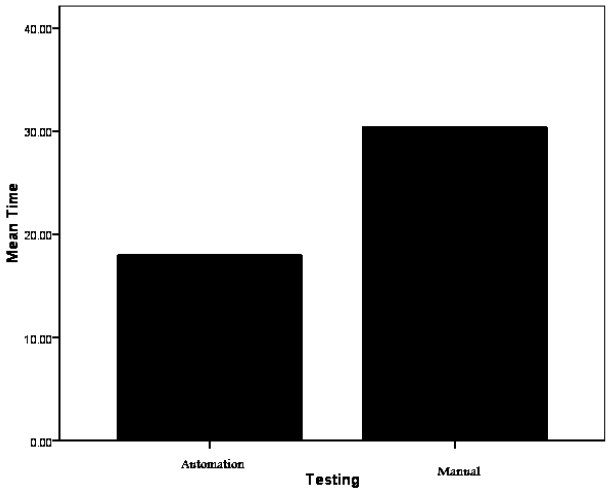

Figure- 7: Automation testing time vs. Manual testing time

Table- 9: No of error identified in Automation testing v . Manual testing

Testing	Functional Errors	Performance Errors	Security Errors
Manual	60-80%	70-80 %	60-89 %
Automation	70-80%	90-99 %	90-99 %

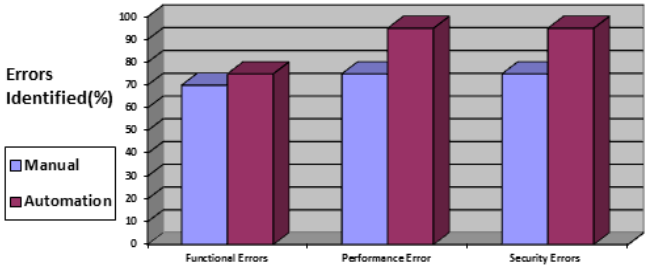

Figure- 8: No of error identified

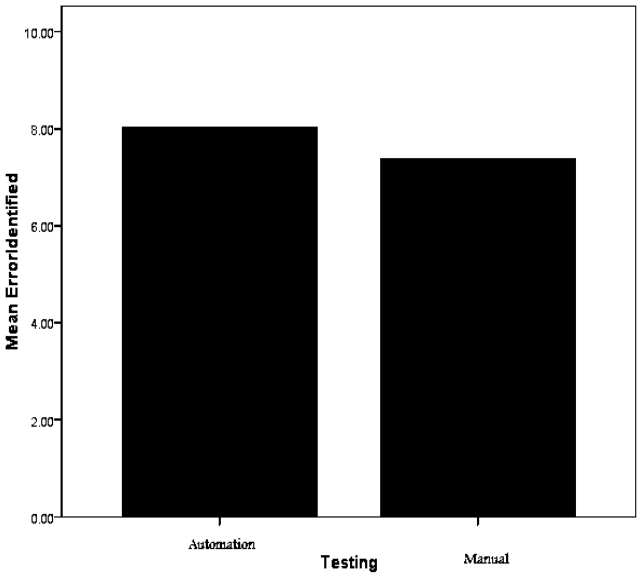

Figure- 9: # of error identified in Automation testing vs. Manual Testing

6. CONCLUSION

To ensure the quality of any software testing is a prime venture in SDLC. A few tests innately oblige an automated methodology to be compelling, however others must be manual. We have observed that

Unsuccessful automated testing projects are expensive. In this research, we have perceived whether to automate a test or run it manually. Our model is based on cost and time spent in testing and number of bugs detected during automated and manual testing approaches. This model will be valuable and steady in choice making whether to trade-off between automated or manual testing.

The Automation cost is higher comparing manual cost considering all licensing and training cost. Especially the factor of licensing of automation tool mainly maximizes the testing cost. Yet in the event that we overlook the aforementioned cost in later releases of projects than the Automation cost is lesser than Manual cost.

On the other hand, automated testing needs a higher initial investment as compare to manual testing but it can reduce the testing associated costs by minimizing the time spent on creating and running the test cases. This reduction of testing cost will appear after a period of time relying on the utilization of automation tools.

The extent that time taken to execute manual test vs. automated test is concerned, the automated testing diminishes the time it takes to complete software testing and allows for increased test coverage. Automation tests saves time during regression testing, performance testing, load testing and stress testing because the script in Auto test is written once but in manual testing we start from the scratch. It is also observed that it is very hard to do regression testing manually; especially in release project because automation performs very well and saves time of testers.

The more prominent quantities of bugs are distinguished via automated testing as compared to manual testing. By analysis of data we have found that automation testing generates best results in functional, performance and security testing. As performance testing includes load testing and stress testing hence it is easily identified in automation testing. During discussion with senior testers, it was revealed that software testing cannot be automated completely. Some tests still have to be done manually. There are specific tests where automated tools are of no use.

APPENDIX

Mathematical Description of Hypothesis-1, 2 and 3

For hypotheses 1, 2 and 3, all have testing variable which has two categories, automation and manual and for this we use T-Test. For example: in the first case, we need to find the relationship between the cost of Automation and Manual testing.

$$t = \frac{\bar{x}\ \mathbf{costAuto} - \bar{x}\ \mathbf{costManual}}{\sqrt{\frac{S^2\mathbf{costAuto} - S^2\mathbf{costManual}}{N}}}$$

In second case, we need to find the relationship between the time taken for Automation and manual testing.

$$t = \frac{\bar{x}\ \mathbf{timeAuto} - \bar{x}\ \mathbf{timeManual}}{\sqrt{\frac{S^2\mathbf{timeAuto} - S^2\mathbf{timeManual}}{N}}}$$

In third case, we need to find the relationship between the Error identified by Automation and manual testing.

$$t = \frac{\bar{x}\ \mathbf{errorsAuto} - \bar{x}\ \mathbf{errorsManual}}{\sqrt{\frac{S^2\mathbf{errorsAuto} - S^2\mathbf{errorsManual}}{N}}}$$

Where:

S^2 = Variance

N = Number of Record

*"In T-Test probability of 0.05 or less is commonly interpreted by social scientists as justification for rejecting the null hypothesis that the row variable is unrelated (that is, only randomly related) to the column variable.***"**

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