

Web Programming and Multi-Tier Architecture of Web Applications

Matija Varga ¹

¹ University North, Trg Žarka Dolinara 1, Koprivnica, Croatia

Abstract – The research paper investigates multi-tiered web application architecture and layers of web application architectures based on relevant literature using the scientific method of content analysis. Based on the results of the research (survey, where the scientific method of surveying based on a sample of 42 respondents), was used information was obtained: (1) whether the respondents had heard of tools and technologies that serve as help in programming and testing, such as: JUnita, Apache JMeter, Mockita, (2) whether the respondents used tools and technologies that serve as help in programming and testing such as: JUnita, Apache JMeter and Mockite, (3) which of the above tools are the best in the opinion of the respondents for help in programming and testing from the above: JUnita, Apache JMeter, Mockite, (4) whether the respondents have used BootStrap so far, (5) what according to respondents BootStrap enables, (6) which tools do web developers prefer to use when programming for the purpose of creating websites (applications), (7) what is most important for respondents in order for a website to be evaluated as successfully created and of high quality, (8) did the respondents know that the multi-layer architecture of web applications consists of a presentation layer, a controller layer, a repository layer, a model layer and an auxiliary layer. The research came to the conclusion that the hypothesis "H₁" was accepted, while H₂ is rejected. In the research, hypothesis H₃ was also rejected, while the alternative hypothesis H₄ was accepted, based on the chi-square test for all tested cases.

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Corresponding author: Matija Varga,
University North, Trg Žarka Dolinara 1, Koprivnica, Croatia
Email: marga@unin.hr

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Keywords – Web programming, multi-layer architecture, web applications, surveying, chi-square test.

1. Introduction

In this research paper on the topic: "Web programming and multi-tier architecture of web applications" the following were investigated: multi-layer web application architecture and layers of web application architecture. During the research, hypotheses were set. The hypotheses are:

H₁: For a successfully created and high-quality web application, the most important are: visual aspects of web pages, the existence of interactive and multimedia elements on the web page, while web developers know the multi-layered architecture of web applications consisting of presentation layer, controller layer, repository layer, model layer, and auxiliary layer,

H₂: For a successfully created and high-quality web application, not only the visual aspects of web pages and the existence of interactive and multimedia elements on the web page are the most important, but web developers do not have sufficient knowledge about the multi-layered architecture of web applications, which consists of presentation layer, controller layer, repository layer, model layer, and auxiliary layer",

H₃: "There is no difference between the answers obtained and the randomly distributed answers" and

H₄: "There is a difference between the obtained answers and randomly distributed answers".

The established hypotheses H₃ and H₄ will be clarified in the fifth chapter, where it will be tested and proven which hypothesis is accepted and which is rejected.

2. Web Application Programming

The Internet is very often used as an effective means of publishing information of all kinds. The web can also be seen as a kind of field for educational hypermedia applications. However, it is difficult to construct responsive, context-based web applications for several reasons, e.g.: static links between documents, the stateless nature of the HTTP protocol, etc.

Despite these problems, authors always create applications, models, languages, etc., to offer adaptive educational applications to students according to their knowledge and skills [1].

Web application programming takes place using the client side (OnSK) on the server side (PnSP). There are several languages for creating web applications, such as (1) descriptive languages, (2) style languages, (3) scripting languages, (4) programming languages, and (5) structured query languages.

3. Multi-Layered Web Application Architecture

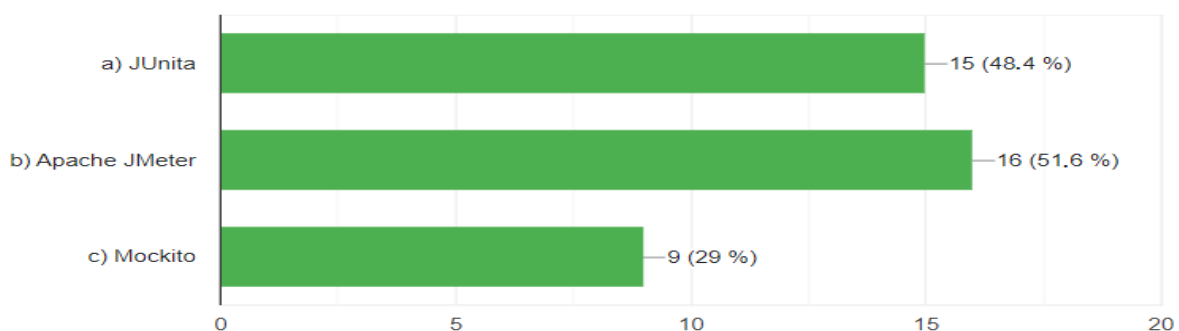
The multi-layer architecture of web applications consists of five layers, namely: (1) presentation layer, (2) controller layer, (3) repository layer, (4) model layer, and (5) auxiliary layer. The controller layer that is part of an MVC (Model-View-Controller) application runs as a 3-tier cloud application [8]. Many developers use MVC as a standard design pattern. It is a complete framework [7]. Among the 5 layers are also mentioned: (1) web client, (2) web application firewall, (3) web application, (4) database firewall, and (5) database server [9]. The controller intercepts client requests, adjusts the model and informs the model about changes in user requests. Controller provides the logic and serves as the interface between the model and the view, which means manages navigation and input [2].

View in MVC-u the view manages the user interface [2]. A view in MVC is what the client sees and changes according to the model. The MVC concept is designed using a CodeIgniter framework [4].

Some authors state that the MVC model has only three key layers, namely: (1) model, (2) view, and (3) controller. In the MVC concept, the design of the information system is divided into three layers, namely the model, the view, and the controller. Models are used to manage information and notify observers when information changes. Only the model contains data and functions related to data processing. It is a view responsible for mapping the graphics to the device. A view usually has a 1-1 relationship with the screen area and knows how to create it. The controller receives input from the user and instructs the model and view to take action based on that input. Separating the model and view allows multiple views to use the same model. Many studies have shown that application development using the MVC concept is better than conventional development [4].

4. Analysis of Research Results-Survey

In the research process, a survey was conducted in which the relevant sample consisted of web programmers, web designers and media experts and, the Internet as a medium of all media. The sample is intentional for the reason that during this research it is necessary to know the population well to be able to choose elements for the sample that will provide the relevant characteristics as needed in the research. Respondents were chosen according to the decision of the researcher (web programmers, web designers, and media and Internet experts). The sample is forty-two respondents ($N=42$). Based on the survey, the following results were obtained (according to the graph images):

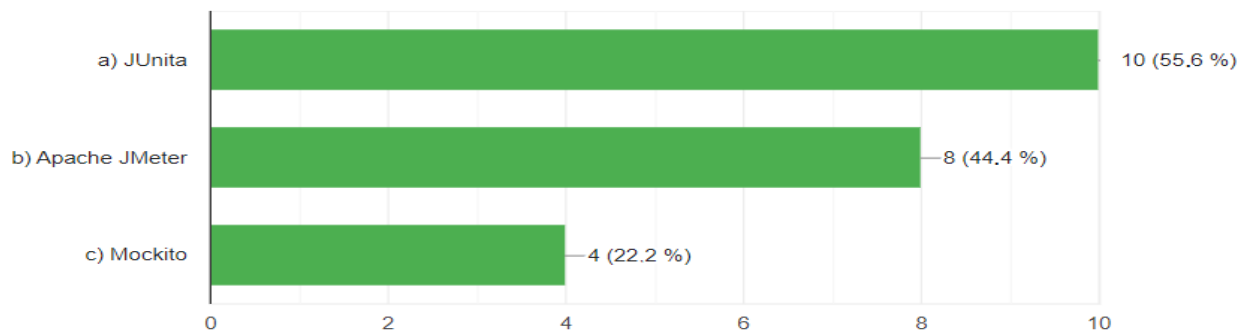


(Source: Creation of the author of the paper based on an online survey. [3])

Figure 1. Presentation of the results obtained by the respondents on whether the respondents have heard of tools and technologies that serve as an aid in programming and testing such as JUnit, Apache JMeter, and Mockito

Figure 1 shows the result obtained by the respondents on whether the respondents have heard of tools and technologies that help in programming and testing such as JUnit, Apache JMeter, and

Mockito. The fewest respondents have heard of the Mockito tool (29%), while the most respondents have heard of the Apache JMeter tool (51.6%). 48.4% of respondents have heard of the JUnit tool.

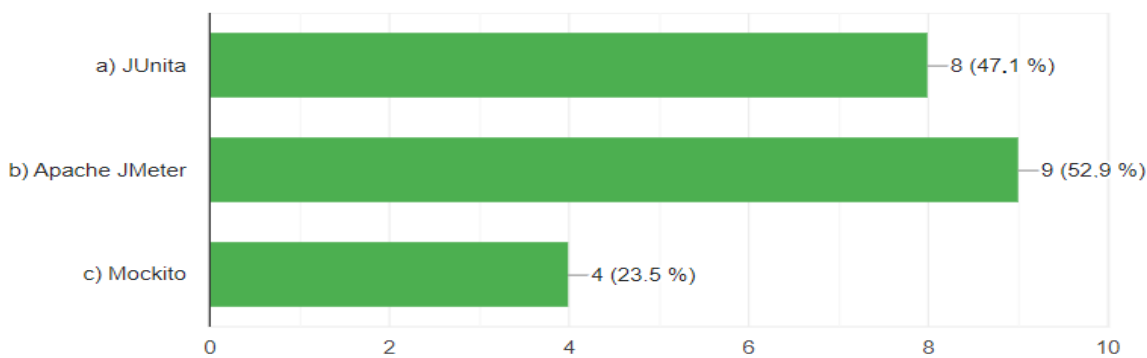


(Source: Creation of the author of the paper based on an online survey. [3])

Figure 2. Presentation of the results obtained by the respondents whether the respondents (if they heard) used tools and technologies that serve as an aid in programming and testing such as JUnit, Apache JMeter, and Mockito

Figure 2 shows the result obtained by the respondents, i.e. whether the respondents (if they heard) used tools and technologies that serve as an aid in programming and testing such as JUnit, Apache JMeter, and Mockito.

Most respondents, 55.6% of them, declared that they used JUnit technology and tools for programming and testing. Apache JMeter was used by 44.4% of respondents, while Mockito was used by 22.2% of respondents.

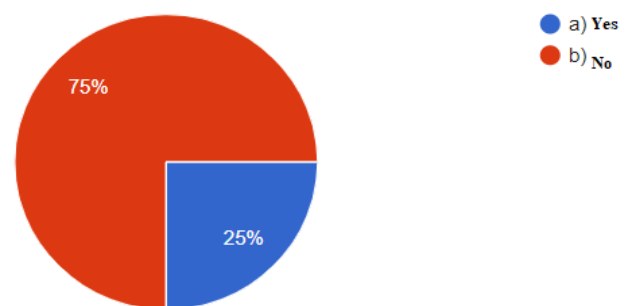


(Source: Creation of the author of the paper based on an online survey. [3])

Figure 3. Presentation of the results obtained by the respondents regarding which of the listed tools (if they used the listed tools) is the best according to the respondents

Figure 3 shows the result obtained by the respondents regarding which of the listed tools (if they used the listed tools) is the best according to the respondents. Most respondents, 52.9% of them, have experience and claim that the best technology is also a tool to help in programming and testing Apache JMeter. In second place is JUnit as the best tool and technology according to 47.1% of the respondents, while in the last place according to the opinion of 23.5% of the respondents is the tool Mockito.

Figure 4 shows the score obtained by respondents on whether respondents used Bootstrap.

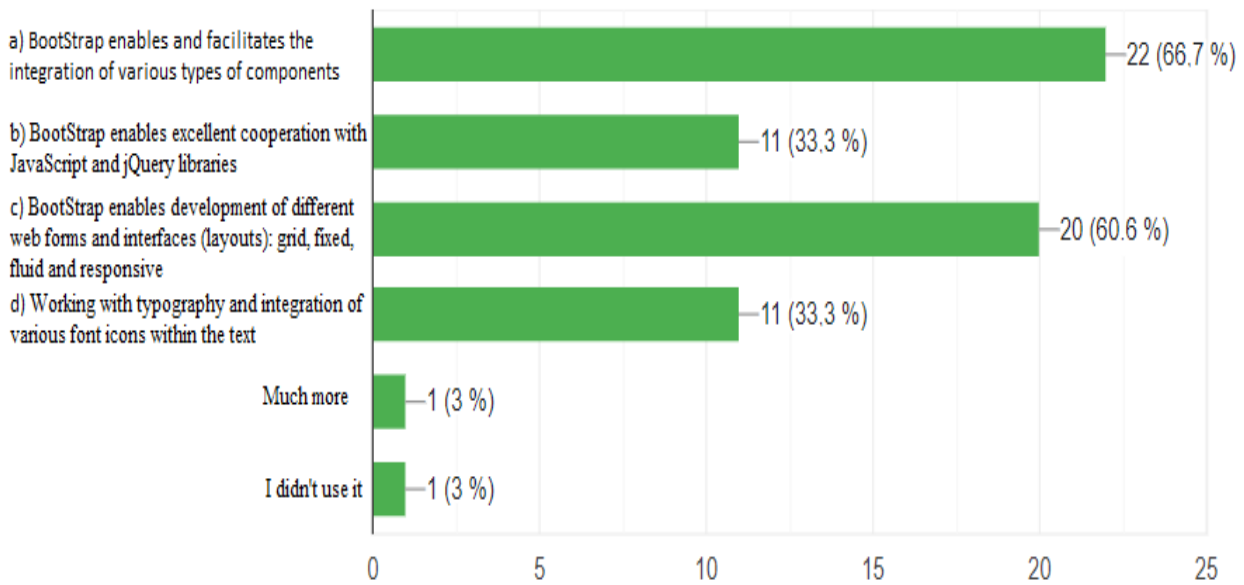


(Source: Creation of the author of the paper based on an online survey. [3])

Figure 4. Presentation of the results obtained by the respondents on whether the respondents used Bootstrap

The majority of respondents 75% did not use Bootstrap, while 25% of respondents said they used Bootstrap as a free and open-source CSS framework

intended for responsive front-end web development primarily for mobile devices.

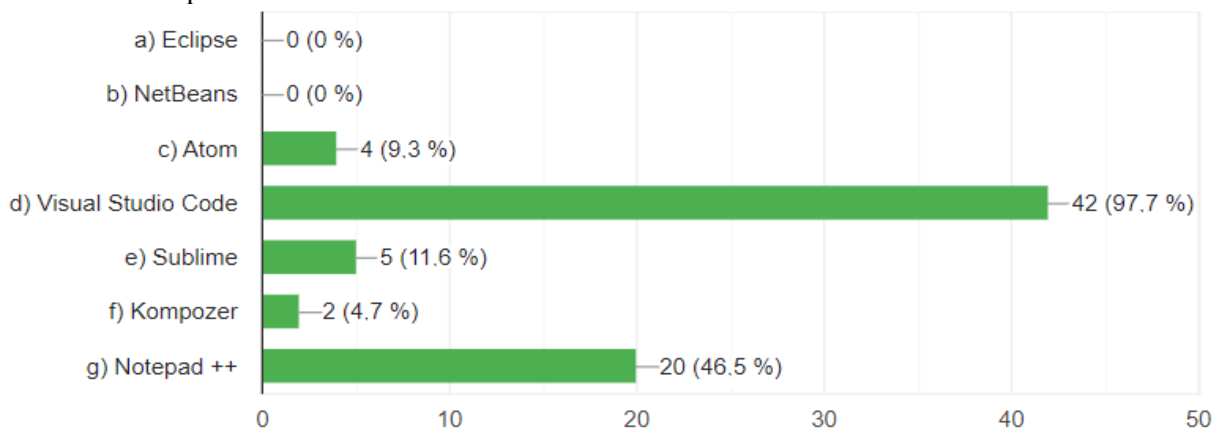


(Source: Creation of the author of the paper based on an online survey. [3])

Figure 5. Presentation of the results obtained by the respondents on what makes everything possible according to the respondents of Bootstrap

Figure 5 shows the score obtained by the respondents on what makes everything possible according to the respondents of Bootstrap. Most respondents, 66.7%, chose the option "a)" as Bootstrap enables and facilitates the integration of various types of components (forms, buttons, actions with text, and other elements), after that 60.6% of respondents chose the option "c)" as Bootstrap enables the development of different web forms and

interfaces (layouts): grid, fixed, fluid, and responsive after that 33.3% of respondents chose options "b)" and "d)" because Bootstrap enables excellent cooperation with JavaScript and jQuery libraries and working with typography and integration of various font icons within the text. The smallest number of respondents, 3%, declared that they had not used Bootstrap until the day of the survey.

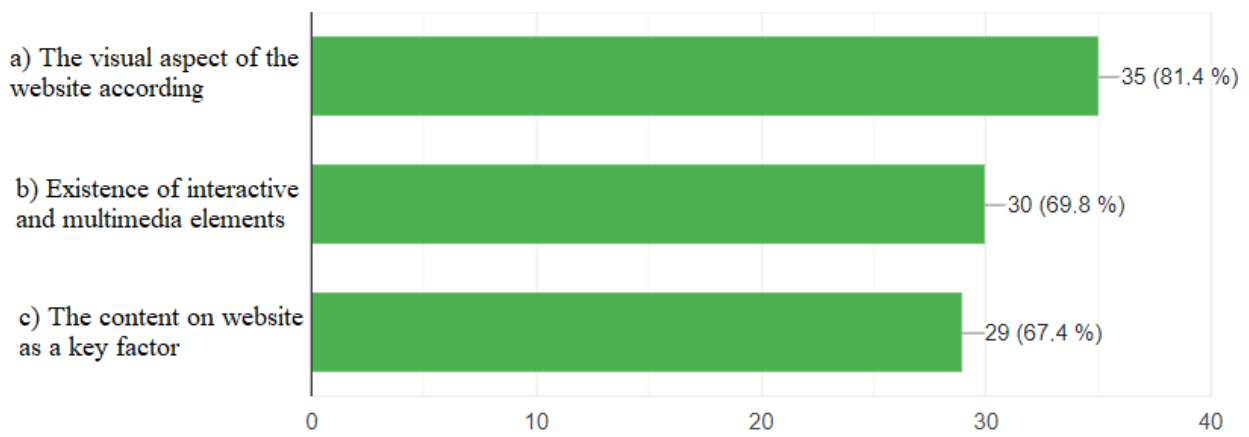


(Source: Creation of the author of the paper based on an online survey. [3])

Figure 6. Presentation of the results obtained by respondents, which of the listed tools they prefer for use to create web pages

Figure 6 shows the results obtained by the respondents, which shows which of the listed tools are preferred by the respondents to use to create websites. Most respondents prefer (97.7%) the tool "Visual Studio Code", followed by 46.5% of respondents "Notepad++", while 11.6% of respondents prefer "Sublime".

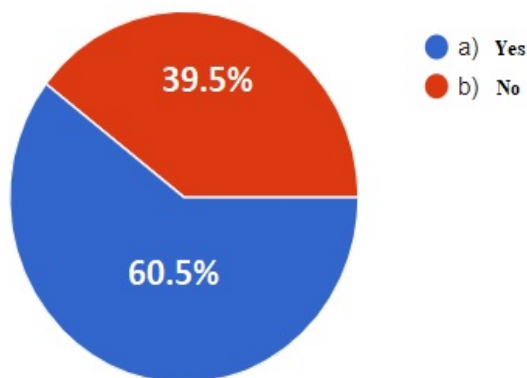
After the mentioned tools, the following are the tools according to the respondents' preference: "Atom" (9.3%) and "Kompozer" (4.7%). The included (sample) respondents do not use tools such as: "Eclipse" and "NetBeans".



(Source: Creation of the author of the paper based on an online survey. [3])

Figure 7. Presentation of the results obtained by the respondents, which, according to the respondents, is the most important for a successfully created and high-quality website

Figure 7 shows what, according to the respondents, is the most important for a successfully created and high-quality website from the above. The most important factors for a successfully created and high-quality website are a) the visual aspect of the website according to 81.4% of respondents, b) the existence of interactive and multimedia elements on websites according to the opinion of respondents and according to the selection of option b) by 69.8% of respondents, and the content on the website as a key factor according to 67.4% of respondents, which contributed to the confirmation and acceptance of hypothesis H_1 , and the rejection of hypothesis H_2 when testing hypotheses.



(Source: Creation of the author of the paper based on an online survey. [3])

Figure 8. Presentation of the results obtained by the respondents on whether the respondents knew that the multi-layer architecture of web applications consists of a presentation layer, controller layer, repository layer, model layer, and auxiliary layer

Figure 8 shows the result obtained by the respondents on whether the respondents knew that the multi-layer architecture of web applications consists of the presentation layer, controller layer, repository layer, model layer, and auxiliary layer. Most of the respondents 60.5% chose the option: "a) Yes" which means that they knew that the multi-layer architecture of web applications consists of (1) presentation layer, (2) controller layer, (3) repository layer, (4) model layer and, (5) auxiliary layer, while the minority with 39.5% chose the option of the survey questionnaire: "b) No". The results from Figure 8 also influenced the hypothesis testing procedure.

Also, based on the answers collected by the respondents using questions seven (7) and eight (8) based on the testing of hypotheses: H_1 and H_2 , the hypothesis: " H_1 " is accepted, which reads: For a successfully created and high-quality web application, the most important are: visual aspects web page, the existence of interactive and multimedia elements on the web page, while web developers know the multi-layered architecture of web applications, which consists of: presentation layer, controller layer, repository layer, model layer and, auxiliary layer.

5. Chi-Square Test

In chapter 5, it will be referred to the analysis of the results of the survey research, and the procedure called the chi-square test will be carried out, which is used in most cases if it is about qualitative data or if the distribution of the data deviates significantly from normal. At the very beginning, it should be emphasized that the chi-square test is calculated with frequencies, and it is not allowed to enter measurement units in the calculation. The basic research data can also be measured values, but only their frequencies are entered into the chi-square [10].

Table 1. Presentation of the counting of respondent's answers to the questions

The timestamp	1. Have you heard of tools and technologies that help in programming and testing like? (mark the ones you've heard of).	2. If you heard, which of the tools did you possibly use?	3. Which of the above tools (if you have used them) do you think is the best?	8. Did you know that the multi-layer architecture of web applications consists of: presentation layer, controller layer, repository layer, model layer and auxiliary layer?	
JUnita	9	8	6	26	YES
Apache JMeter	10	6	7	16	NO
Mocktio	6	2	2		

(Source: Creation of the author of the paper based on an online survey and LibreOffice Calc tools. [3])

Table 1 shows the counting of respondents' answers and the function applied: COUNTIF.

Table 2. Presentation of the chi-square test for answers to the 1st question of the online survey

	a) JUnita	b) Apache JMeter	c) Mockito	Total:	Shared:	
f_0	9	10	6	25	8.3333	f_0
f_t	8.33	8.33	8.33	24.99		f_t
	f_0	f_t	$f_0 - f_t$	$(f_0 - f_t)^2$	X^2	
	9	8.33	0.6700	0.4489	0.0539	
	10	8.33	1.6700	2.7889	0.3348	
	6	8.33	-2.3300	5.4289	0.6517	
				Hi square:	1.0404	

(Source: Creation of the author's paper based on an online survey and the LibreOffice Calc tool.)

Table 2 shows the chi-square test for the answers to the 1st question of the online survey. The sum of chi-squares is: 1.04042. Namely, the third hypothesis H_3 was put forward, which reads:

There is no difference between received responses and randomly distributed responses, while the alternative hypothesis H_4 reads: There is a difference between received responses and randomly distributed responses. If the answers were given completely randomly, each of them would have the same probability, so each answer is expected: $25/3=8.33$ times.

Thus, the expected frequency for each response would be 8.33.

The results are presented in Table 2. Also in the second part of the table, the data needed in the formula are calculated. The principle of interpretation of the obtained chi-square result: if no differences were found between the observed and expected frequencies, the chi-square expression would be 0, the greater the differences between the observed and expected frequencies, the greater and definitive the chi-square expression.

Therefore, the smaller the chi-square, the more likely it is that the stated hypothesis H_3 should be accepted, and the higher the chi-square, the more likely it is that the stated hypothesis should be rejected and the alternative hypothesis H_4 accepted, because the observed results differ significantly from those expected under a certain hypothesis. The table of chi-square limits shows up to which value (with a certain number of degrees of freedom) it is considered that the chi-square is still high enough to reject the hypothesis, i.e. what is the minimum chi-square value for rejecting the hypotheses.

As a general rule, the fact that the center value of the chi-square with a given degree of freedom is approximately as many degrees of freedom as there are, hence, can serve as a rule of thumb. Therefore, hypothesis H_3 can possibly be accepted (without looking at the chi-square table) if the obtained chi-square is less than or equal to the number of degrees of freedom. In this case, the sum of the chi-squares based on Table 2 (Σ chi-square) is 1.04042, based on the answer to the 1st question, which means that the hypothesis H_3 is rejected and the alternative hypothesis H_4 is accepted [5].

Table 3. Presentation of the chi-square test for answers to the 2nd question of the online survey

	a) JUnita	b) Apache JMeter	c) Mockito	Total:	Shared:	
f_0	8	6	2	16	5.3333	f_0
f_t	5.33	5.33	5.33	15.99		f_t
	f_0	f_t	f_0-f_t	$(f_0-f_t)^2$	X^2	
	8	5.33	2.6700	7.1289	1.3375	
	6	5.33	0.6700	0.4489	0.0842	
	2	5.33	-3.3300	11.0889	2.0805	
				Hi square:	3.5021	

(Source: Creation of the author's paper based on an online survey and the LibreOffice Calc tool.)

Table 3 shows the chi-square test for the answers to the 2nd question of the online survey. In this case, the sum of the chi-squares based on Table 3 (Σ chi-square): 3.50219, based on the answer to the 2nd question, which means that the hypothesis H_3 is rejected and the alternative hypothesis H_4 is accepted in this case as well.

Table 4 shows the chi-square test for the answers to the 3rd question of the online survey. In this case, the sum of the chi-squares based on Table 4 (Σ chi-square) is 2.8, based on the answer to the 3rd question, which means that hypothesis H_3 is rejected and the alternative hypothesis H_4 is accepted in this case as well.

Table 4. Presentation of the chi-square test for answers to the 3rd question of the online survey

	a) JUnita	b) Apache JMeter	c) Mockito	Total:	Shared:	
f_0	6	7	2	15	5	f_0
f_t	5	5	5	15		f_t
	f_0	f_t	f_0-f_t	$(f_0-f_t)^2$	X^2	
	6	5	1	1	0.2000	
	7	5	2	4	0.8000	
	2	5	-3	9	1.8000	
				Hi square:	2.8000	

Source: Creation of the author's paper based on an online survey and the LibreOffice Calc tool.)

Table 5. Presentation of the chi-square test for answers to the 8th question of the online survey

	a) Yes	b) No		Total:	Shared:	
f_0	26	16		42	14.0000	f_0
f_t	14	14		28		f_t
	f_0	f_t	f_0-f_t	$(f_0-f_t)^2$	X^2	
	26	14.00	12.0000	144.0000	10.2857	
	16	14.00	2.0000	4.0000	0.2857	
				Hi square:	10.5714	

(Source: Creation of the author's paper based on an online survey and the LibreOffice Calc tool.)

Table 5 shows the chi-square test for answers to the 8th question of the online survey. In this case, the sum of the chi-squares based on Table 5 (Σ chi-square): 10.5714, based on the answer to the 8th question, which means that the hypothesis H_3 is rejected and the alternative hypothesis H_4 is accepted in this case, as well [6].

6. Conclusion

Based on the results of the research, the conclusion was reached that the hypothesis " H_1 " was accepted, which reads: For a successfully created and high-quality web application, the most important are: visual aspects of web pages, the existence of interactive and multimedia elements on the web page, while web developers possess knowledge of multi-layered architecture web application consisting of: presentation layer, controller layer, repository layer, model layer, and auxiliary layer. Also, based on the research, it was found out that the respondents heard about the Apache JMeter tool the most "times", i.e. the tool and technology most familiar to the respondents in their opinion: Apache JMeter (51.6%). Most of the respondents used a tool and technology to help with programming and testing: JUnit (55.6%), while the largest percentage of respondents (52.9%) said that the best tool was Apache JMeter. Bootstrap is still not used by the majority of respondents (75% of respondents do not use Bootstrap while 25% of respondents use Bootstrap). According to respondents, Bootstrap enables and facilitates: (1) integration of various types of components (forms, buttons, actions with text and other elements), (2) enables the development of various web forms and interfaces (layouts): grid, fixed, fluid and responsive and (3) cooperation with JavaScript and JQuery libraries, and work with typography.

According to the conducted research, users prefer to use Visual Studio Code to create websites (97.7% of respondents), while the most important thing for a successfully created and high-quality website is the visual aspect of the website and the existence of interactive and multimedia elements. Also, it should be noted that the research hypothesis H_3 , which reads: There is no difference between received answers and randomly distributed answers, was rejected, while the alternative hypothesis H_4 , which reads: There is a difference between received answers and randomly distributed answers, was accepted, based on a hi-square test for all tested cases (i.e. cases 1, 2, 3 and 4).

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