Bootstrap as a Tool for Web Development and Graphic Optimization on Mobile Devices

Oscar López-Gorozabel, Emilio Cedeño-Palma, Jenmer Pinargote-Ortega, Walter Zambrano-Romero, and Marcos Pazmiño-Campuzano

Facultad de Ciencias Informáticas, Universidad Técnica de Manabí, Portoviejo, Ecuador
{olopez7574, emilio.cedeno, maricela.pinargote, walter.zambrano, marcos.pazmino}@utm.edu.ec

Abstract. The advance of technology requires that people need publicity and administrative advice of their business through the Web. It is there where the role of the web developer appears since this topic must make use of the appropriate tools that enhance their work. The style pages have been facilitating the elaboration of web pages for some years now. However, programmers have not created any framework to optimize the size of the interfaces automatically.

By doing so, navigation from any device without any anomaly. Currently, the massive use of mobile devices requires the optimization of the design of the graphic interfaces developed for computers to the resolution of mobile devices. One could say that this motivated the company Twitter in 2011 to create Bootstrap, a framework with the function of adjusting the resolution of websites that can be developed from a computer and then be displayed correctly in the different screen resolutions of mobile devices.

This article tries to orient the evaluation of the Bootstrap tool for the re-engineering of the web system “EducArte Comunidad” interacting with the following design languages: HTML5, CSS, and JQuery. Specifically, this research is carried out based on the observation in the development of computer applications under the multiplatform modality.

Keywords: Websites · Bootstrap · Graphic languages · Adaptive frame · Graphic interfaces

1 Introduction

1.1 Evolution of Online Computer Systems

Web systems have evolved rapidly, and then desktop systems have been left behind. Some companies have migrated their obsolete systems to the web, as online services provide users with faster data processing and improved information availability.

According to [10], in his article on the development of the educational platform Zera (Cuba), he expresses that the use of the Bootstrap framework facilitated the programming of interfaces and improved the user experience in navigation from any mobile device.
On the other hand, [15] state in their article on M-learning, that educational systems must currently focus on pocket technology, that is, mobile devices and tablets that facilitate the learning process at an economic level. For this reason, we intend to perform the re-engineering of the EducArte Comunidad system since the system only has a presentation for computers, but it will be taken to the mobile part through adaptability.

Following the line of development of educational systems, [7] considers that the use of languages that provide adaptability, especially Bootstrap allowed the library web system of the University of Maryland to be adaptable. This adaptability allowed access through cell phones and tablets. The results of this implementation were beneficial by improving the number of virtual visits and users experiences.

There is no doubt that the adaptable aspect in the development of applications is an advantage when it comes to creating systems. Therefore, [9] states that predecessor websites were created with design aspects that were only relevant to PCs. This type of development posed a large number of problems, having to create a different design for each device where the application was running. To solve this problem, Bootstrap was implemented in the graphic interfaces of the Juang Restaurant System, finally generating an optimal presentation in the content displayed on mobile devices.

This situation, according to [3], is conducive to the emergence of receptive websites, such as the SANEC Portal, which was developed with the methodology of adaptability, seeking to adjust the desktop system to all mobile devices, increasing the number of visits exponentially. Likewise, the aim is to reach the demand of users in the EducArte Community system. Currently, frameworks dedicated to web interfaces are so important as to improve the visual interaction between the user and a computer system. According to [11], the most used framework nowadays is Bootstrap, due to the ease and resources it offers to create web interfaces.

The development of this adaptive web system has social importance for the benefit of the community to be implemented in vulnerable sectors, where children and young people have the facility to access the services offered by the system through a mobile device. The reason is that almost every home has a mobile device and not a computer due to economic difficulties. Therefore, with the development of this web system, we intend to reduce the limitations in the design and architecture of the “EducArte Comunidad” system, opening the way to the m-learning paradigm, conditioning the availability of its contents and its correct functioning in mobile devices. All this, to present one of the main results achieved in the research related to the adaptive web, highlight the theoretical references that support the solution.

2 Materials and Methods

The methodology of this research is of a bibliographic and experimental nature. Applied analysis and synthesis is made to summarize the theories on which the research is based, citing the criteria of web development experts on the Bootstrap framework and its characteristics, to conclude the importance and guarantee of its use for the graphic optimization of web applications. The following aspects will be studied in depth: definition of Bootstrap, its main characteristics, the compatible browsers, the types of language it integrates. Attached to the above, the following items will also be detailed:
• Definition of Bootstrap principles and usability guidelines.
• Experimentation and evaluation of the “EducArte Community” web system, which will be re-engineered with Bootstrap.

2.1 Bootstrap for the Production of Web Systems

Nowadays, you can find tools for web design, which Twitter developed for those users who do not have much knowledge in HTML and CSS programming. It is worth emphasizing that there is currently a fine line between designers and programmers in this area of development, making possible the creation of ideal tools for creative processes, which contribute to the development of software without previous knowledge of engineering [13].

[21] defines that: The user regularly changes electronic devices. Therefore, programmers must develop web systems to adapt to a variety of resolutions, specifically image size and command sequences. In short, the web system must automatically respond to different devices to satisfy user preferences. The adaptive design of Bootstrap is based on the use of third level style sheets with CSS Media Queries, which allows styles to be applied depending on the size of the screen on which the web system is displayed. According to [17], Bootstrap has surprising features for front-end development, being visually coupled to the needs and experiences of the user, the features presented are:

- It allows the insertion of several elements online: icons, drop-down menus, combining HTML5, CSS and Javascript languages.
- The design will be adaptable, not affected by the scale or resolution of the mobile device.
- The design of columns is faster and easier to configure.
- It integrates with the main Javascript and Media Queries libraries.

Responsive Web System Against Mobile Applications

For [20], the application can read user contacts, calendars, photo galleries, and other resources. But in the case of a web system, it does not allow access to system resources. A difference in compatibility that exists in web development is that the development code of the mobile application depends on the phone manufacturer; at the same time, any mobile browser can read the HTML-based web system. On the other hand, the user must download the application and its updates separately, which will not be necessary for receptive systems.

2.2 Screen Adaptation on Mobile Devices

For [1], small screen mobile devices are gaining popularity as time goes by. Video game consoles and smart TVs are also becoming more common among consumers, as they allow them to browse the Internet on high-resolution devices in comfort.

That is why web developers have begun to bet on the graphic adaptability of systems in a wide variety of screen resolutions, with the primary objective of giving the user maximum usability and presentation of content in a clean and appropriate. Below, Table 1
shows the visualization preference that users have on a website, a survey conducted by Google in 2014 [14].

Table 1. Preference in screen accuracy according to Google users.

| Range accuracy (px) | Popularity (%) |
|---------------------|----------------|
| 1366 × 768          | 20.74          |
| 1024 × 768          | 9.61           |
| 1280 × 800          | 9.35           |
| 1920 × 1080         | 6.63           |
| 1440 × 900          | 5.44           |
| 768 × 1024          | 5.26           |
| 1280 × 1024         | 5.22           |
| 1600 × 900          | 4.14           |
| 320 × 480           | 2.90           |

Source. Data taken from a Google survey published by W3C.

Composition of the Adaptive System
According to [9], when the Internet became widespread in the 1990s. It was usual for web systems to be compiled into a spreadsheet structure. Tables were the only effective way to link text and graphics. These issues occurred when sites became more sophisticated and extensive, and table structures were transformed into more complex nested tables.

File Download Formats
For [6], Bootstrap is free to download and also for unlimited commercial use, allowing web designers to use it as a tool to create web systems for different purposes. The source code contains the files Bootstrap CSS, Less, which is a CSS extension, Javascript, and other original fonts, as well as documentation. These files can be found in GitHub.

2.3 Preparing Bootstrap for Web Development
[3] defines that: Bootstrap contains compiled and compressed source code, as well as versions of CSS, JavaScript, and font files. Also, when downloading it, the files will be extracted to the root of the web system to link locally in the document header. The Bootstrap file structure consists of three folders: css, js, and fonts. We can recognize compressed files by the min file name. These files contain the same code as the translated files but are compressed, which takes less time to download from the server.

    Bootstrap file structure (see Fig. 1).
Compressed files can be recognized by the .min file name. To access or read Bootstrap files it is recommended that they are compressed [14].

Bootstrap Compatibility and Support
Bootstrap is compatible with the latest versions of desktop and mobile browsers. When running on older browsers, it differs in style, functionality, and performance of some components. In Windows, Bootstrap runs in Chromium, Chrome, and Firefox browsers, which are not officially compatible. However, the network version allows them to automatically link to the repositories where the Bootstrap libraries are located. On the other hand, it unofficial sources state to work quite well with Linux [12] (Fig. 2).

Grid System
[14] claims that:

Bootstrap always works with a sensitive and predefined grid system that is distributed in the twelfth column. The grid system creates a design with content, on the site divided into sets of columns and rows. The grid system is surrounded by a div.container (fixed width).container-fluid (adaptive width) element. A line is then inserted into the container. (Row).

```
<div class = “container”>
  <div class = “row”> </div>
</div>
```

The site columns are integrated into the rows. The purpose of the rows is to divide the columns into horizontal groups. The site content is placed within individual columns.

```
<div class = “container”>
```

You can use the HTML table containing the line (tr) to help outline the structure of the cell (td). The content of the table, such as text, graphics, and so on, is written inside the cell. The height of cells determines the height of the row around them. In a grid system, columns are similar to cells in a table, since the site content is embedded. The row always begins with a new group of columns. Unlike a grid, rows can contain a different number of columns [14].

The spacing of the columns is 15 pixels by default on the left and right sides created by the fill. Because the column fill is at both edges, the content area of the first and last columns in the row is not aligned with the container. The left and right borders were created for columns with negative margins at-15 pixels. This will change the position of the first and last columns in the row so that their content area is aligned with the container [14]. Bootstrap has a total of four predefined breakpoint definitions for columns: lg, md, sm, and xs (Table 2).

**Table 2.** Acceptance of breakpoints in pixels.

| Category         | Width in pixels | Devices               |
|------------------|-----------------|-----------------------|
| .col – lg- *     | >1200           | Large desks           |
| .col – md- *     | >992            | Small desks           |
| .col – sm- *     | >768            | Tablets and small screens. |
| .col – xs- *     | <768            | Smart phones          |

**Source.** Own Elaboration

**Breakage Points**

For [14], a website can be divided into four columns when viewed on a desktop screen. In tablet view, the columns are divided into two rows and there are only two columns next to each other. In a cell, columns are always 100% wide, unless you specify a separate column. xs- * category.
Graphics Window Configuration
According to [8], is the visual area in which documents are displayed in HTML, is where primarily applies a scalability to the interface, this is done because you must set a value for mobile devices, then detaches some attributes that has the graphical window:

- **Width**: device width or number of pixels.
- **Height**: height of the device or value in pixels.
- **Initial scale**: 0–1 (1 indicates that it is not scaled).
- **User scale**: yes/no (indicates if the user can change the scale).
- **Minimum scale**: 0–1 (minimum scale of the graphic window).
- **Maximum scale**: 0–1 (maximum scale of the graphic window).

**To apply a receptive design:**

```html
<meta name="viewport" content="width=device-width, initial-scale=1.0"/>
```

**For mobile devices, it is preferable to disable the zoom:**

```html
<meta name="viewport" content="width=device-width, initial-scale=1.0, maximum-scale=1.0, user-scalable=no"/>
```

3 Implementation of Bootstrap in the EAC EducArte Community Web System

See (Fig. 3)

![Web system “EducArte Community”](image)
The EducArte Comunidad system is an educational web platform dedicated to offering diverse knowledge courses to the communities of the city of Portoviejo, Ecuador. This system is accessible without registration costs. It was developed by the student author of this article, belonging to Faculty of Computer Science at Technical University of Manabí. The software has efficient functions in the backend, but in the frontend aspect, only CSS style sheets are utilized. They were not optimal due to the exuberant coding, and therefore the lack of graphic adaptability in mobile devices. In the next section, we will present some code fragments where Bootstrap was implemented to give the educational system an automatic resolution adjustment. In the reengineering of the system, the linked Bootstrap libraries will be used online (Fig. 4).

The following code details the creation of the login with Bootstrap classes, using the div constant for the separation of text entry: email and password (Fig. 5).

Using the nav_link class, a vertical drop-down bar is being created, which is located on the left side of the interface (Fig. 6).

Sidebar with Bootstrap. With these lines of code you could create a horizontal navigation bar, with multiple options, commonly called nabvar (Fig. 7 and Fig. 8).
4 Results and Discussions

During the Covid-19 pandemic, it is clear that not every family has a laptop or a desktop computer for online activities, but they generally do have a smart cell phone. According to [4], he states that the process of incorporating ICT into education is a fundamental
Bootstrap as a Tool for Web Development and Graphic Optimization

Component in the development of education in the 21st century. In this sense, the indicators of acceptability in cellular networks and the use of mobile devices to access the Internet in Latin America show a growing and highly favorable scenario for educational processes mediated by mobile devices. This issue is due to their adaptation to the system in which we live, where there is a tendency to different anomalies (pandemics, civil wars, among others). Time is money, and an adaptative application would avoid increases in its creation. According to [20], several tools integrate Bootstrap for the development of web systems and save development time. They are Pingendo, Brix, Jetstrap, Pinegrow, Bootstrap Studio, Bootply, Bootmetro, JSfiddle with Bootstrap, among others.

Emphasizing a tool that could allow the accelerated development of interfaces would be Bootstrap Studio, as it is considered a Web 2.0 tool due to its synchronization of graphic libraries and database integration. As mentioned [2], at present, the potential of the cell phone as an educational tool would improve the presentation and availability in time and resource of computer applications, such as the case of (DpWcE) “Web page design in educational contexts”. This design was a Spanish educational system of the UNED for the doctoral process. This web portal was developed under the W3C standard by using layout languages and CSS dynamics. It is worth mentioning that the results of this article indicate the importance of migrating the desktop aspect to the mobile one to detect user satisfaction and an increase in the number of visits.

Following the same line of research, for [18], the application of Bootstrap in the Web System of the Faculty of Computing and Informatics (University of Malaysia) improved performance on mobile devices. According to the experimental results, the Page Speed Insights tool indicated that mobile speed scores increased from 27/100 to 91/100 after the Bootstrap framework was implemented. On the other hand, speed scores for the desktop also increased from 28/100 to 97/100. Besides, the Web Page Test tool revealed that the loading time decreased from 10,175 s to 3,099 s after optimizing the responsiveness of the website. The following paragraphs will detail the values corresponding to navigation speed, loading time, and the number of weekly visits, both on mobile and desktop of the EAC (EducArte Comunidad) platform. The data could be estimated thanks to the software Page Speed Insights of Google, which allows analyzing the performance of web portals. Likewise, the Google Analytics API was used to measure visits to the portal (Table 3).

Table 3. Assessment of browsing speed, loading time, number of visits and adaptability of the EAC Web System.

| Measured aspects          | Tools                  | Portal with bs | Portal without bs |
|---------------------------|------------------------|----------------|-------------------|
| Navigation speed          | Page speed insights     | 1, 7 s         | 2, 0 s            |
| Charging time             | Page speed insights     | 1, 7 s         | 2, 0 s            |
| Number of visits to the portal | Google analytics       | 75 users       | 45 users          |
| Adaptability according to Woorank analysis | Woorank analytics | 100% adaptive | No BS Compressed css files |

Source. Own Elaboration
After analyzing the web system EAC in its two versions, it was possible to obtain a positive result in terms of browsing performance: The implementation of BS manages to minimize with 3 ms, the loading time, and browsing speed concerning EAC without BS. On the other hand, it was possible to increase the audience of the portal through the Google Analytics tool. The access to the portal has increased from 45 to 75 users. In summary, EAC users feel satisfied because they can navigate from their mobile devices (Table 4).

Table 4. User experience through surveys in Google forms

| User experience                                      | Answers         |
|------------------------------------------------------|-----------------|
| How do you consider the navigation quality of EAC with Bootstrap on your mobile device? | High (40)       |
| How do you consider the navigation quality of EAC without Bootstrap on your mobile device? | Under (45)      |
| In which presentation do you like the EAC system best? | With Bootstrap (50) |
| Regarding the loading speed of the system, which one do you think is slower? | EAC without BS (35) |

Source. Own Elaboration

The data obtained through the experience questionnaire shows that for users, Bootstrap improves the presentation and adaptability of interfaces, including in aspects of load and runtime. According to [19], they state that the use of responsive tools potentially improves the presentation of web portals, bypassing mobile development, and allowing obsolete systems (desktop) to apply re-engineering. Also, the web education service “Labyrinth” that, after being a desktop system, transformed it into an adaptive web system supported by a cloud infrastructure to update it. We concluded that the re-engineering done was the optimal solution to improve the availability and performance of the system.

Also, the EAC portal improved its availability, speed of navigation, and loading time. Also, its amount of code decreased because Bootstrap contains embedded code that allowed through a sentence to design essential components, such as login, navbars, jumbotrons, footers, tables, warning messages, among others.

5 Conclusions

The use of Bootstrap allows the adaptation of web environments to different devices, without the need for operating systems, so it is an advantage in time and money, which is what currently would be convenient for companies. There is no doubt that this “responsive” movement has come to have an impact on user access to different websites. The company Google has incorporated into its servers the use of these graphic libraries that
allow users to upload sites to the Internet and make them adaptable. Finally, the objective of this article is to present the web system “EducArte Comunidad” to the population of “El Florón” in the future. Children from this community will have the facility to access the services offered by the system through a mobile device since it is evident that almost every family has a smart device and not a computer due to financial difficulties. The supported data collected by a survey conducted last year by the author of this article, where it is evident that the majority of the population has smart mobile devices and not computers.

Finally, positive results were achieved with the reengineering of the EAC Web System, improving graphic and navigation aspects, such as 100% adaptability to various mobile devices, loading time, and system speed. In the analysis, it was also possible to diagnose that Bootstrap increased the weight of the system because it creates strings of code through its graphic libraries. This disadvantage was diagnosed but ignoring that small excess, it improved the appearance and speed of the system and, therefore, satisfied users. The advantages provided by Bootstrap had an impact on the increase in the audience of the EAC web system. Currently, the system is available at the address: eacomunidad.xyz, where the system will appear in its two versions: with BS and without BS. As future improvements, they will try to create modules such as online chat, library, academic activities, games, among other interactive modules. It is worth noting that it seeks that this system in the future is free software, becoming a significant contribution to distance education or online, for schools, colleges, and inclusive universities. There is no doubt that this “responsive” movement has come to have an impact on user access to different websites. The company Google has incorporated into its servers the use of these graphic libraries that allow users to upload sites to the Internet and make them adaptable. Finally, the objective of this article is to present the web system “EducArte Community” to the population of “The Florón” in the future. Children from this community will have the facility to access the services offered by the system through a mobile device since it is evident that almost every family has a smart device and not a computer due to financial difficulties. The supported data collected by a survey conducted last year by the author of this article, where it is evident that the majority of the population has smart mobile devices and not computers.

References

1. Afia, Z., Syed, J., Khurram, S., Usman, A.: The users experience quality of responsive web design on multiple devices. In: ICFNDS 18: Proceedings of the 2nd International Conference on Future Networks and Distributed Systems (2018). https://dl.acm.org/doi/abs/10.1145/3231053.3234632
2. Brazuelo, F., Cacheiro, M.: Design of Educational web pages for mobile phones. Electronic magazine of educational technology (2010). https://www.edutec.es/revista/index.php/edutec-e/article/view/437/172
3. Carranco, J., Maya, E.: Design and development of the adaptive web portal of SANEC (Ecuadorean sanctuaries) in the diocese of Ibarra. Magazine UTN (2016). http://repositorio.utn.edu.ec/bitstream/123456789/5611/3/ARTICULO.pdf
4. Chiappe, A.: Trends in digital educational content in Latin. Cuaderno SITEAL UNESCO (2016). https://unesdoc.unesco.org/ark:/48223/pf0000245673
5. Danlin, O.: Responsive web design and php e-commerce. Conferences THESEUS (2018). https://www.theseus.fi/handle/10024/153778
6. Git Hub. Git HUB Wbs/bootstrap: The most popular HTML, CSS, and JavaScript framework for developing responsive, mobile first projects on the web (2016). https://github.com/twbs/bootstrap
7. Glassman, N., Shen, P.: One site fits all: responsive web design. J. Electron. Res. Med. Lib (2015). https://www.tandfonline.com/doi/abs/10.1080/15424065.2014.908347
8. Jiang, W., Zhang, M., Jiang, Y., Zhang, Y.: Responsive web design mode and application. In: Workshop on Advanced Research and Technology in Industry Applications (WARTIA) (2015). https://ieeexplore.ieee.org/document/6976522/
9. Lee, J., Jung, M., Kim, H.: Responsive web design according to the resolution. IEEE Explore (2016). https://ieeexplore.ieee.org/abstract/document/7434345
10. Manso, Y., Cañizares, R., Febles, J.: Responsive web design for educative platform ZERA. Cuban J. Comput. Sci (2016). https://rcci.uiuc.edu/?journal=rcci&page=article&op=view&path%5B%5D=1048&path%5B%5D=422
11. Marcotte, E.: Responsive Web Design. A List Apart (2011). https://alistapart.com/article/responsive-web-design/
12. Nilesh, J.: Review of different responsive css front-end frameworks. J. Glob. Res. Comput. Sci (2014). http://www.rroij.com/open-access/review-of-different-responsive-css-frontend-frameworks.pdf
13. Pekka, J., Solanen, T.: On the design of a responsive user interface for a multi-device web service. In: 2nd ACM International Conference on Mobile Software Engineering and Systems (2015). https://ieeexplore.ieee.org/abstract/document/7283029
14. Peltomäki, V.: Bootstrap Framework as a web design tool (2014). https://www.theseus.fi/bitstream/handle/10024/74557/Peltomaki_Veera.pdf?sequence=1&isAllowed=y
15. Pisanty, A., Enríquez, L., Chaos, L., García, M.: “M-learning en ciencia” - Introducción de aprendizaje móvil en física. RIED. Revista Iberoamericana de Educación a Distancia, 13(1), 129–155 (2010). http://dx.doi.org/10.5944/ried.1.13.892
16. Powers, D.: Introduction to media queries. Adobe Developer Connection (2011). https://www.adobe.com/devnet/archive/dreamweaver/articles/introducing-media-queries.html
17. Rodríguez, R., Vera, P., Marko, I., Zain, G.: Adaptive web frameworks analysis based on html5. XX Workshop of Researchers in Computer Science (2018). https://pdfs.semanticscholar.org/69a6/6e9bd643c94c561f1c1895af7c4ce199a4b.pdf
18. Shan, T., Obit, J., Rayner, A., Tahir, A.: Enhancing the Performance of University’s Website for Mobile Devices Based on Responsive Web Design Approach. American Scientific Publishers (2017). https://www.researchgate.net/publication/322098135_Enhancing_the_Performance_of_University's_Website_for_Mobile_Devices_Based_on_Responsive_Web_Design_Approach
19. Stočes, M., Masner, J., Jarolímek, J., Šímek, P., Vaněk, J., Ulman, M.: Cross-Platform user interface of E-learning applications. 11th International Conference Mobile Learning (2015). https://files.eric.ed.gov/fulltext/ED562430.pdf
20. Suraj, G., Adkar, P.: A review paper on bootstrap framework. IRE J. (2019). https://irejournals.com/formatedpaper/1701173.pdf
21. Thomas, A., Walsh, P., Kapfhammer, M.: Automatic detection of potential layout faults following changes to responsive web pages. IEEE Explore (2015). https://ieeexplore.ieee.org/abstract/document/7372059