

The Role of Responsive Design in Web Development

Fernando Almeida

Centre for Innovation, Technology and Entrepreneurship, INESC TEC, Porto, Portugal.

E-mail: almd@fe.up.pt

José Monteiro

Higher Polytechnic Institute of Gaya, ISPGaya, V.N.Gaia, Portugal. E-mail: jam@ispgaya.pt

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Abstract

Responsive design allows software developers to build a Web page that can dynamically adapt to the size of the devices. This development philosophy enables the rendering of Web pages in a fast and optimized way, ensuring a good user experience on mobile devices, tablet and desktop. In the scope of this study, we intend to explore the main advantages and limitations associated with responsive Web design. We adopted a quantitative approach based on a questionnaire filled by 181 professionals in the industry that allowed us to identify the reasons that lead software developers to the adoption of the responsive design and also address the limitations felt by them. The results obtained indicate that offering a good user experience and increasing accessibility stands out as being the most important advantages. On the other hand, the main limitations include the compatibility with older Web browsers, the higher loading time and the difficulties in optimizing user experience. Finally, it was found that the perception of the advantages and limitations of responsive design is distinct for professionals with more professional experience in the field and for freelancer developers.

Keywords

Web development; Responsive design; Web designing; User experience

Introduction

The advent of the Web turned possible the appearance of new form of transmission ideas and contents in online environments. The Web design process uses techniques to adequate structuring of information, using appropriate resources to serve on web pages, in a manner that the user can reach his goal in a direct and pleasant way.

Web design distinguishes itself from other traditional forms of design. The Web is a unique channel that forces designers not to be able to control the environment around them. Elements such as colors, shapes, and layouts can be customized by the user (or by the users' web browser), and there are no guarantees that all users will see the same Web page in the same way that it was designed and developed. In this sense, Web designer need to concept Web applications, without knowing in advance the Web browsers that will be used, the technological platform on which application will be run, such as operating systems, personal preferences of users, resolution of the access devices, and the characteristics and speed of the Internet connection.

Consequently, it is pertinent to explore Web design models and techniques that could partially mitigate the above identified issues. One of the most popular techniques is the responsive Web design, which is a technique that allows a website to adapt to the device where a page is being accessed (e.g., desktop, laptop, tablet or a smartphone). Currently the number of scientific studies in the field of responsive design is very low, and most of them only perform a comparative analysis of the responsive design against the adaptive approach and the native process of building an Android or iOS app. Studies analyzing the benefits and limitations of responsive design are essentially opinion-based, which are based on the personal experience of Web and mobile developers. This paper discusses the role of the responsive Web design and explores the main reasons for its adoption and also the limitations felt by web developers. The paper is structured as follows: we initially perform a revision of literature in the field by characterizing the evolution of Web paradigm and presenting the concept of responsive design. After that initial phase, we present the structure of the adopted methodology. Then, the results of the study are presented and discussed. Finally, the conclusions of this work are drawn.

Literature Review

The evolution of Web paradigm

The Internet is an essential tool for citizens, businesses and public entities. Since its appearance, a number of significant changes have arisen, from the most basic paradigm of Web 1.0 to Web 4.0. The first phase of the Web, known as Web 1.0, is characterized by static content publishing, in which users had the power to only consume the content placed by companies. At that time, there was no bidirectional communication between the client and a company, and email emerged

as the primary form of digital contact between these two entities. Web 1.0 is characterized by its low interactivity. Companies used the Internet as an alternative channel to publish content and news, without worrying much about users' opinions, who behaved like a passive viewer of information.

The number of Internet users has been growing and it was progressively verified that their needs directly influenced the way companies use their resources and tools (Dooley et al., 2012). These changes forced the emergence of a new environment, known as Web 2.0, whose main characteristic is its high interactivity. Web 2.0 includes a large and diverse panoply of services, such as social networks, blogs and wikis, that promote collaboration and the fast exchange of information among users. Andriole (2010) states that Web 2.0 has helped companies to become more competitive and position themselves in the marketplace. The main advantage associated with Web 2.0 is its potential in establishing collaboration, and the main disadvantage is the loss of control of the shared information.

The growth of Web 2.0, particularly with the exponential expansion of social networks, created in a few years a huge amount of information about the users. This information is a valuable asset for the definition and personalization of marketing and business strategies in the most varied sectors of activity. In this sense, Web 3.0 emerged as a new paradigm that allowed companies to explore this information about users, in order to identify trends and optimize their experiences on the Web. With the appearance of the Web 3.0 has become much easier to find relevant information on a given subject. However, as a major disadvantage, it can appear security issues, such as unauthorized access and manipulation of data (Rudman & Bruwer, 2016).

Web 4.0 emerges currently as a new paradigm arising from the technological advances of mobile devices, Internet of things and ad-hoc networks. Web 4.0 proposes a new model of interaction that is more complete, dynamic and personalized, in which there is a symbiotic interaction between humans and machines (Choudhury, 2014).

The concept of responsive design

Website design is a crucial point in a website development process. It involves the arrangement of content into graphical models that can be used as a basis for coding a site (Almeida & Monteiro, 2017). The increasing number of Internet users and mobile devices, such as smartphones and tablets, has caused a need to adapt the content displayed on each device. The idea of designing multiple versions of the same site to attend each size of screen and resolution would not be possible, because it would originate impractical costs and a high maintenance effort.

Responsive design emerges as a technical solution that mitigates this issue, since a website dynamically adapts to the width of the device in which is being visualized. Subic et al. (2014)

state that the content of a website should intelligently re-shaped itself for maximum usability and impact. In this way, the HTML and CSS code of a website is adapted to the resolution of the device without having the need to define different styles. Responsible web design is composed by three technical components (Cazañas & Parra, 2017): (i) fluid grids, (ii) flexible images; and (iii) media queries. Fluid grids are responsible to assign relative units to page elements; flexible images are also sized in relative units; and media queries make possible to switch between different CSS based on the features of the device. An example of a website built using the responsive design is given in Figure 1.

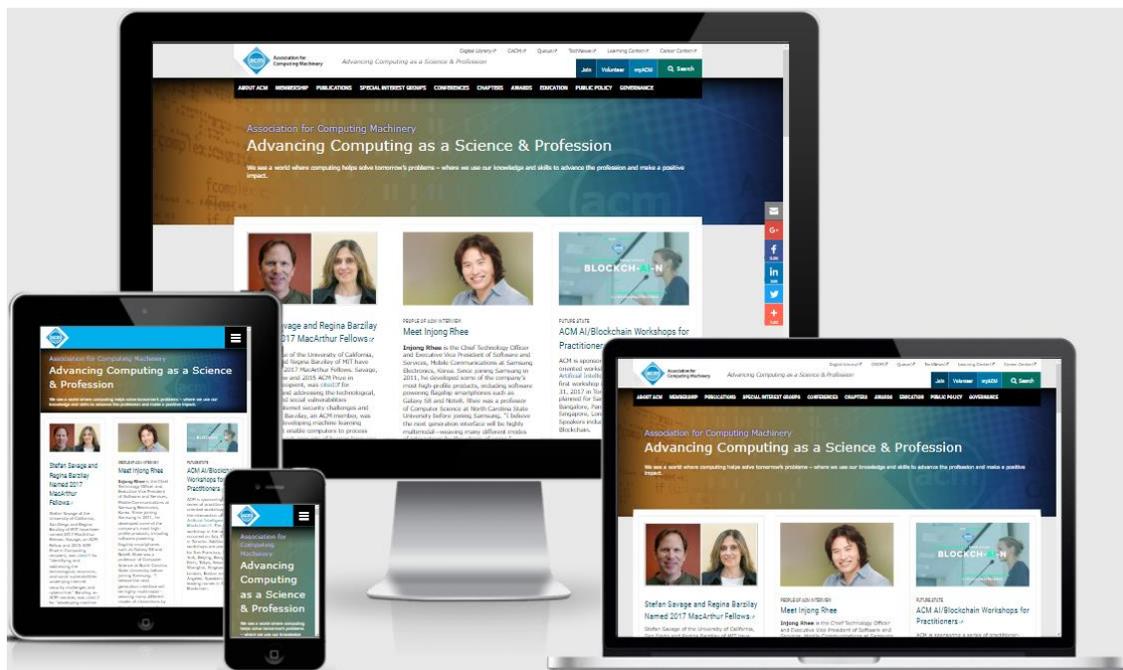


Figure 1. Responsive design of a website with various screen sizes and resolutions

Creating responsive design includes: (i) tailoring the page layout to the resolution of the device; (ii) resize the images automatically to they fit on the screen; hide unnecessary elements in smaller devices; (iii) adapt size of buttons and links to touch interfaces where the mouse pointer is replaced by the user's finger; and (iv) use intelligently features in mobile devices, such as geo-localization and changing the orientation of the content view.

The loading time of a website is one of the most critical aspects of building a responsive design. Paying attention to image size is critical for ensuring that responsive websites load quickly and deliver the best experience for mobile users. A survey conducted by Trilibis identified that a total of 123 in 155 responsive sites performed badly on mobile phones (Trilibis, 2014). A good solution is to adopt server-side image optimization, which will reduce image weight and page-load time. Cao (2017) also confirmed that image size is a cause for the bad loading time performances, but he also identified eight elements that can potentially cause performance issues

in Web responsive design, such as: (i) bloated, untidy code; (ii) plugins; (iii) themes; (iv) under-optimized images; (v) poorly constructed responsive design; (vi) render-blocking JavaScript and CSS; (vii) lack of GZIP compression; and (viii) poor server setup.

A debate point in the community is the adoption of native apps or mobile Web apps. Native apps typically offer better performance since they work with the device's built-in features. On the other hand, web apps built using responsive design paradigm are much easier to maintain, because they have a common code base across multiple mobile platforms. Jobe (2013) identified that mobile Web applications that require hardware interaction, such as using the GPS, GPU, or camera, are not yet good alternatives for native applications. On the other hand, White (2013) considers that mobile Web development approach is more suitable for apps that have a lot of content delivered via web and when they need to be updated regularly and quickly.

Hybrid mobile development approaches have also appeared in recent years. The idea is to avoid the need of implementation the same application for different platforms separately, allowing developers to extend the number of platforms which can run the application. Additionally, the web-based nature of this approach ensures that the application must not necessarily be platform-specific (Rakestraw et al., 2013). Numerous frameworks appeared in the market, such as PhoneGap, Adobe Air, Ionic, or QT. Alqahtani & Goodwin (2012) use PhoneGap to build a mobile e-commerce application, integrating simultaneously design and security non-functional requirements. Martin et al. (2014) uses PhoneGap to build a Web and mobile application for the management of payments for a fleet of vehicles using the "Via Verde" device. Finally, Litayem et al. (2015) propose the use of a hybrid approach for the development of mobile learning platforms. The result is a more compatible and more stable cross-platform learning application specifically for quizzes and assignments.

There are several advantages associated with responsive design approach. Lestari et al. (2014) advocate that responsive web design is a suitable approach to offer improve user experiences. Majid et al. (2015) consider that responsive design is a highly flexible approach that can be used for the development of e-commerce solutions to improve SEO. Rashid (2017) consider that there are five essential reasons that support the great growth of responsive design, respectively: (i) increased traffic from mobile users; (ii) lower cost and website maintenance; (iii) provides a seamless user experience; (iv) adapts easily to any screen size; and (v) improves SEO efforts. Owens (2015) defines the concept of website bounce rate as "the percentage of people who visit your site and leave after viewing only one page" and advocates that responsive web design may play a relevant role in decreasing the website bounce rate. Winkless (2015) suggests that responsive web design contributes to increase the productivity of web designers. Finally, Baker (2014) advocates that web responsive design, namely the use of HTML5 and CSS level 3, promotes the creation of accessible web pages.

On the other hand, we also identified in the literature some disadvantages of responsive Web design. Soegaard (2017) presents two main limitations of responsive design: (i) difficulties in optimizing user experience due to bad content adaptation; and (ii) higher loading time. Glassman & Shen (2014) reports issues when adopting responsive design in complex projects and difficulties to integrate with CSS media queries. Finally, Tranfici (2013) states that CSS3 is not widely supported in all older browser versions.

Methodology

This study aims to understand the main potentialities and limitations of responsive design in the perspective of software developers. Four research questions (RQs) are defined:

- RQ1 – What is the perception of software developers on the main benefits and limitations of responsive design?
- RQ2 – Do the benefits and limitations of responsive design are different for professionals with more professional experience as software developers?
- RQ3 – Do the benefits and limitations of responsive design are different for professionals with more experience in developing websites with responsive design?
- RQ4 – Do the benefits and limitations of responsive design are different for professionals working in different sectors of activity?

The study adopts a quantitative approach based on a questionnaire created using the Google Drive platform and delivered it through two professional LinkedIn groups in the Web design field, and in a [forum](http://www.webdeveloper.com/forum) (www.webdeveloper.com/forum) that is specially dedicated to Web developer practices. The questionnaire was available during the entire month of November 2017.

Questionnaires offer several important benefits. According to Queirós et al. (2017), they are high representativeness of the entire population and a low cost method when compared to other alternatives. In fact, since the same question is answered by several respondents, then this reduces the possibility of evaluator bias. Additionally, tabulation of closed-ended responses is an easy and straightforward process (Singer & Couper, 2017). However, there are some issues when adopting Web questionnaires that should be properly mitigated. Fricker and Schonlau (2002) report that Internet-based surveys typically achieve very low response rates, expect when using university-based populations or small specialized populations. Therefore, the survey was only disclosed to a target audience that is potentially interested in the results of this investigation, hence their motivation to participate in this study was also higher. Finally, it is important to mention that the use of surveys does not allow exploring the causes and reasons for each of the respondents' answers. In this sense, it was considered from the literature review that there are already some exploratory studies of a qualitative nature that approach the advantages and limitations of Web responsive design, but that there is a deficit in the analysis of the relative importance of each of them.

The questionnaire is composed of 18 questions divided into three sections (i.e., contextual, benefits, and limitations). The “contextual data” section, together with the last two, allows us to respond to RQ2, RQ3 and RQ4. To answer the RQ1 we would only need the last two sections of the questionnaire. The purpose of each section is detailed in Table 1.

Table 1. Structure of the questionnaire

Section	Description
Contextual data	Information regarding the type of sector of activity and experience of the software developer.
Benefits analysis	List of benefits associated to responsive design.
Limitations analysis	List of limitations associated to responsive design.

In the last two sections of the questionnaire, we use a multiple choice grid with a Likert scale. This approach guarantees that respondents can easily and quickly answer the questionnaire, because they are restricted to a finite set of responses. Furthermore, this approach allows new questions to be easily incorporated into the questionnaire without changing its structure.

The Likert scale is composed of five levels, such as: 1. strongly disagree; 2. disagree; 3. neither agree nor disagree; 4. agree; and 5. strongly agree. Likert scale data is considered suitable for qualitative nature studies, in which statistical processes can be applied for data analysis (Hartley, 2014). According to Boone & Boone (2012), the following statistical methods can be applied: (i) mean for central trend analysis; (ii) standard deviation for variability analysis; (iii) Pearson's coefficient for association analysis; and (iv) ANOVA, t-test and regression as other statistical elements.

The Cronbach's Coefficient Alpha is adopted to evaluate the reliability of the questionnaire structure. The coefficient adopts a scale between 0 and 1 and it should be greater than or equal to 0,7 to verify the homogeneity of the items of the same construct (Tavakol & Dennick, 2011; Cho & Kim, 2014). Data presented in Table 2 demonstrate that Cronbach's Coefficient Alpha is always higher than this reference value for all questionnaire sections.

Table 2. Reliability analysis of constructs

Construct	Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	No. of Items
Contextual data	0,7283	0,7296	3
Benefits analysis	0,8825	0,8841	8
Limitations analysis	0,8152	0,8162	6

Finally, data were statistically analyzed using Stata software. Stata is a statistical reference application in the scientific community that allows analyzing data using methods of descriptive statistical analysis and statistical inference (Hamilton, 2012). In the context of this study, Stata was used to perform the following operations: (i) descriptive analysis of the data; (ii) analysis of the robustness of the constructs; and (iii) hypothesis testing based on the mean.

Analysis and Discussion of Results

We obtained a total of 181 valid responses, respectively: 103 responses from private companies; 33 from public companies, and 45 from freelancers' professionals. Around 57% of our respondents are currently working on private companies. Table 3 organizes the data considering the different years of professional experience, and Table 4 displays it considering the different years of experience working with responsive design.

Table 3. Data frequency organized by years of professional experience

Years of professional experience	Type of company			Total
	Private	Public	Freelancer	
Less than a year	8	0	16	24
Between 1 and 3 years	25	7	17	49
Between 3 and 5 years	43	13	9	65
More than 5 years	27	13	3	43
Total	103	33	45	181

Table 4. Data frequency organized by years of experience working with responsive design

Years of experience working with responsive design	Type of company			Total
	Private	Public	Freelancer	
Less than a year	21	3	30	54
Between 1 and 3 years	46	11	13	70
Between 3 and 5 years	31	11	2	44
More than 5 years	5	8	0	13
Total	103	33	45	181

The obtained data enable us to characterize the profile of our respondents. The majority of respondents (35, 91%) have between 3 and 5 years of professional experience as software developers. Despite this, the number of years using responsive design is generally lower than the number of years of professional activity, since most respondents indicate that experience in using this technology is between 1 and 3 years (38, 67%). It should also be noted that a minority of 13, 26% respondents have less than one year of professional experience, while only 7,18% of them have more than 5 years of experience in the use of responsive design.

RQ1 – What are the main benefits and limitations of responsive design?

Table 5 summarizes statistical information regarding all the benefits offered by responsive design presented in the survey. The variables with a higher mean are: (i) good user experience; (ii) increases accessibility; (iii) increases productivity; and (iv) high flexibility. On the other hand, the benefits considered less relevant are: (i) low maintenance time and costs; and (ii) lower bounce rate. All these last two variables have a mean less than 3. The standard deviation of the variables allows us to know which benefits have greater and less dispersion. It is emphasized that there is a greater dispersion of opinions regarding the low time and cost in the development of an application. On the other hand, there is a greater

agreement of opinions regarding the importance given to the good user experience and the potential offered by responsive design in increasing accessibility. Finally, it is relevant to analyze the behavior of benefits offered by responsive design by analyzing the statistical elements related to median, mode and percentiles (P25 and P75). At this level, there is an absolute agreement between the values of median and mode, except for the variable "low development time and costs". It can be seen that the variables "good user experience" and "increases accessibility" have a positive asymmetry, while the variables "low maintenance time and costs" and "improved SEO" offer negative asymmetry. In relation to the remaining variables, we can state that they are approximately symmetric.

Table 5. Descriptive statistical analysis of the benefits

Benefits	Mean	Median	Mode	Std. dev.	P25	P75
High flexibility	3,873	4	4	0,789	3	4
Good user experience	4,376	4	4	0,652	4	5
Low development time & costs	3,464	3	4	0,853	3	4
Low maintenance time & costs	2,669	3	3	0,789	2	3
Improved SEO	3,530	4	4	0,711	3	4
Lower bounce rate	2,972	3	3	0,741	2	3
Increases productivity	3,901	4	4	0,700	4	4
Increases accessibility	4,354	4	4	0,656	4	5

Creation of a good user experience is currently considered as a key element in customer retention. Lacaden (2017) states that the responsive design capabilities are not limited to the adaptation of contents to small-sized devices, but also offer easier readability and faster accessibility. This situation becomes even more pertinent in the context of ubiquitous computing systems as Hansen (2016) advocates that there is a need to explore the area of experience designer and user experience methodologies when creating ubiquitous computing environments. Therefore, it is not surprising that these two benefits stand out from the others (offer a mean higher than 4).

For its part, Table 6 presents a summary of the main elements of descriptive statistics related to the limitations of responsive design. The top 3 most relevant limitations are: (i) browser compatibility with older versions; (ii) higher loading time; and (iii) difficulties in optimizing user experience. On the other hand, the respondents indicated that the other limitations present in the survey are not relevant (mean below 3). It should be mentioned that there is a significant difference between the three most important limitations and the remaining ones. This situation is easily identifiable by looking at the values of the median and mode, which only in the first case are greater than 3. Most of the variables are approximately symmetric, and the limitation relative to compatibility with older browser versions is the only one with negative asymmetry. It should be mentioned that there are no variables with positive asymmetry. Finally, the variable "difficulties in optimizing user experience" presents greater variability.

Table 6. Descriptive statistical analysis of the limitations

Limitations	Mean	Median	Mode	Std. dev.	P25	P75
Bad content adaptation	2,033	2	2	0,795	2	2
Difficulties in optimizing user experience	3,083	3	3	0,894	2	4
Higher loading time	3,354	3	4	0,772	3	4
Not suitable for complex projects	1,945	2	2	0,815	1	2
Availability of CSS media queries	1,906	2	1	0,841	1	3
Browser compatibility with older versions	3,459	4	4	0,703	3	4

Cross-browser incompatibility problems are common in Web development. At this level, we highlight the studies developed by Choudhary (2011) and Patidar et al. (2017), which presents a methodology for detecting cross-browser issues in Web applications and the study by Ochin (2011) the causes for the existence of incompatibility between browsers. In this domain, seven causes are identified: (i) HTML tags; (ii) Cascading Style Sheets (CSS); (iii) font rendering; (iv) Document Object Model (DOM); (v) scripts; (vi) addons; and (vii) third party entities. Campbell (2014) states that most advantages of responsive Web design request the use of browsers with strong CSS3 support. To address this issue in older browsers, it suggests the use of JavaScript solutions such as Respond.js, Modernizr and Adaptive.960.js.

Finally, it should be noted that the loading speed of a website is an important element not only in creating a good user experience, but also in the positioning of the site in a Web search engine (Costill, 2014; Anderson, 2017). In fact, the responsive design process is not an immediate process and requires a dynamic adaptation of the contents. Elements such as the number of CSS files and a high number of components' dependencies can take longer time to download.

Considering RQ1 we realize that among the three main advantages of responsive design are the ease of creating a good user experience, the promotion of accessibility and the contribution given to increasing productivity. On the other hand, among the three main limitations we may find browser compatibility issues with older versions, higher loading time and difficulties in optimizing user experience.

RQ2 – Do the benefits and limitations of responsive design are different for professionals with more professional experience as software developers?

We intend to analyze if the benefits offered by the use of responsive design are different according to the years of professional experience in the area of software development. For that, we perform a two-tailed t-test in order to find evidence of a significant difference between the means of answers provided by respondents with more than 5 years and between 3 and 5 years of professional experience. We adopt a significance level of 5% ($\alpha = 0.05$). Looking at Table 7 is it possible to conclude that the variables “low development time and costs”, and “low maintenance

time and costs” present significant mean differences. In fact, the importance given to these two benefits is less for respondents with professional experience in the area of software development. Most existing studies emphasize the ease of creating a website using responsive design, but ignore the impact on its maintenance in the medium and long term. Cao (2015) mentions that developing a website in responsive design may take longer than using an adaptive design approach. Harris (2015) considers that sometimes it is preferable to use a few specific layouts, instead of considering just one layout that can work in any screen size. This seemingly interesting approach makes the maintenance process more complex, particularly when we have to maintain several layouts, which require extra attention to the site's CSS and organization of contents. This situation is more easily perceived by developers with greater years of experience.

Table 7. Hypothesis test for the benefits of responsive design

Benefits	Mean of all answers	Mean (>5 years)	Pr(T > t)	Mean (between 3 and 5 years)	Pr(T > t)
High flexibility	3,873	3,674	0,0886	3,800	0,4251
Good user experience	4,376	4,279	0,3456	4,308	0,3703
Low development time & costs	3,464	3,047	0,0062	3,415	0,6020
Low maintenance time & costs	2,669	2,349	0,0134	2,523	0,1125
Improved SEO	3,530	3,326	0,0554	3,446	0,3431
Lower bounce rate	2,972	2,814	0,2154	2,938	0,7109
Increases productivity	3,901	3,698	0,0917	3,877	0,7572
Increases accessibility	4,354	4,279	0,5248	4,277	0,2822

Table 8 analyzes the behavior of the various limitations of responsive design. It is verified that the variable "bad content adaptation" is the only elements for which significant mean differences are verified for professionals with more than 5 years of experience. Rice (2015) highlights the existence of three types of problems that face the adoption of responsive websites: (i) image placement; (ii) screen squeeze; and (iii) perspective shift. It is plausible that these problems are more easily identifiable in developers with greater years of experience.

Responding to RQ2 we realize that the perception of the benefits and limitations of responsive design is slightly different for professionals with more than 5 years of experience as software developers. We verified that these professionals consider the costs and time of development and maintenance to be less relevant and indicate that responsive design sometimes presents some difficulties in the adaptation of contents.

Table 8. Hypothesis test for the limitations of responsive design

Limitations	Mean of all answers	Mean (>5 years)	Pr(T > t)	Mean (between 3 and 5 years)	Pr(T > t)
Bad content adaptation	2,033	2,279	0,0264	2,092	0,5107
Difficulties in optimizing user experience	3,083	3,233	0,2337	3,185	0,2903
Higher loading time	3,354	3,558	0,1000	3,385	0,7169
Not suitable for complex projects	1,945	2,140	0,1823	1,938	0,9406
Availability of CSS media queries	1,906	1,977	0,5658	1,815	0,3576
Browser compatibility with older versions	3,459	3,581	0,2787	3,523	0,4692

RQ3 – Do the benefits and limitations of responsive design are different for professionals with more experience in developing websites with responsive design?

Another point that deserves our attention is the analysis of the behavior of the benefits and limitations associated with the responsive design considering professionals with a greater number of years of experience using responsive design. It should be mentioned that this analysis is different from the previous one, since there may be professionals with several years of experience in the area of software development, but who have only recently begun to use responsive design. Looking at Table 9 we found that the variables "low development time and costs", and "low maintenance time and costs" present significant mean differences for professionals with more than 3 years of experience working with responsive design. This conclusion is similar to RQ2, and it can be concluded that professional experience in the information technology sector has an impact on the less perceived benefits associated with the low development time and maintenance of a technology solution based on responsive design.

Table 9. Hypothesis test for the benefits of responsive design

Benefits	Mean of all answers	Mean (>5 years)	Pr(T > t)	Mean (between 3 and 5 years)	Pr(T > t)
High flexibility	3,873	3,769	0,6152	3,841	0,7851
Good user experience	4,376	4,154	0,2674	4,364	0,8871
Low development time & costs	3,464	3,462	0,9938	3,182	0,0427
Low maintenance time & costs	2,669	2,692	0,9308	2,318	0,0057
Improved SEO	3,530	3,385	0,5579	3,364	0,1484
Lower bounce rate	2,972	3,000	0,9036	2,864	0,3528
Increases productivity	3,901	3,846	0,7789	3,773	0,2158
Increases accessibility	4,354	4,308	0,7956	4,273	0,4185

Table 10 presents a similar analysis but considering the limitations of responsive design. There are no significant mean differences between the considered limitations, unlike the previous

scenario in which the variable "bad content adaptation" presented a higher average. One of the reasons that may justify this occurrence is the relatively low number of respondents who have an experience higher than 3 years in responsive design development.

Regarding RQ3 we have found that experience in the field of software development and knowledge in using responsive design have a similar impact. The differences between RQ2 and RQ3 are not statistically relevant.

Table 10. Hypothesis test for the limitations of responsive design

Limitations	Mean of all answers	Mean (>5 years)	Pr(T > t)	Mean (between 3 and 5 years)	Pr(T > t)
Bad content adaptation	2,033	2,231	0,3448	2,182	0,1799
Difficulties in optimizing user experience	3,083	3,000	0,7204	3,182	0,4255
Higher loading time	3,354	3,385	0,8881	3,432	0,4392
Not suitable for complex projects	1,945	2,154	0,4185	1,886	0,6085
Availability of CSS media queries	1,906	1,846	0,7921	1,977	0,5804
Browser compatibility with older versions	3,459	3,462	0,9908	3,568	0,3811

RQ4 – Do the benefits and limitations of responsive design are different for professionals working in different sectors of activity?

Finally, we analyze whether the benefits and limitations of responsive design differ according to the sector of activity of the developers. We considered three, sufficiently generic and comprehensive, sectors of activity: (i) private; (ii) public; and (iii) freelancer. Freelancers are defined in our work as a professional that works by its own, providing services to companies or individuals in an autonomous way.

Analyzing Table 11, there are only significant mean differences for the private and freelancer sectors. In private companies, there is a lower perception of the advantages related to development time and maintenance costs. This is the only indicator for which there are significant statistical differences. The biggest differences are for freelancers, who have a greater awareness of the benefits offered by responsive design in terms of time and costs of development and maintenance, and increased SEO. Freelancers are also less aware of the limitations of responsive design in the loading time of a website and in compatibility with older Web browsers.

We intend to understand the reasons that explain a greater difference in the perception of benefits and limitations for freelancers. The literature doesn't address this situation and, therefore, we judge the behavior of these variables against the typical profile presented by a freelancer. Traditionally a freelancer is a developer with less experience in the information technology sector, with a significant number of them being young graduates or students still attending higher

education. In this sense, it is likely that freelancers will have a stricter knowledge of the different technologies and view responsive design as a quick and versatile way of creating a responsive website. In this sense, their practical perception of the entire software development cycle, which necessarily includes maintenance, is lower than for other professionals. This situation also explains that many of them do not experience so many difficulties in compatibility with older browsers, since in most of these projects already they are working exclusively with browsers with support for HTML5 and CSS3.

Responding to RQ4 we realize that the perception of benefits and limitations of responsive design is distinct for private companies and particularly for freelancers. Private companies manifest a lower perception of benefits associated with costs and time of development and maintenance. On the other hand, the biggest differences are among the freelancers who have a greater positive perception of the advantages related to the time and costs of maintenance and development and also in the contribution given by the responsive design to increase the SEO. Regarding the limitations, we perceive a less consideration of the impact of responsive design in loading time of a website and the existence of compatibility issues with older versions of a Web browser.

Table 11. Hypothesis test for the impact of different sector of activity

	Mean of all answers	Independent variable Sector of activity = "private company"		Independent variable Sector of activity = "public entity"		Independent variable Sector of activity = "freelancer"	
		Mean	Pr(T > t)	Mean	Pr(T > t)	Mean	Pr(T > t)
Benefits							
High flexibility	3,873	3,854	0,7893	3,667	0,1171	4,067	0,1842
Good user experience	4,376	4,369	0,9090	4,242	0,1361	4,489	0,3411
Low development time & costs	3,464	3,330	0,0764	3,394	0,6692	3,822	0,0116
Low maintenance time & costs	2,669	2,501	0,0375	2,758	0,5031	2,978	0,0063
Improved SEO	3,530	3,437	0,1685	3,455	0,5465	3,800	0,0164
Lower bounce rate	2,972	2,883	0,2139	3,000	0,8215	3,156	0,1293
Increases productivity	3,901	3,806	0,1359	3,939	0,7197	4,089	0,1444
Increases accessibility	4,354	4,311	0,4733	4,273	0,4221	4,511	0,1873
Limitations							
Bad content adaptation	2,033	2,107	0,3138	2,121	0,5409	1,800	0,0788
Difficulties in optimizing user experience	3,083	3,194	0,1886	3,121	0,7686	2,800	0,0736
Higher loading time	3,354	3,485	0,0639	3,394	0,7609	3,022	0,0111
Not suitable for complex projects	1,945	1,903	0,5757	2,091	0,3274	1,933	0,9332
Availability of CSS media queries	1,906	1,961	0,5283	1,879	0,8621	1,800	0,3112
Browser compatibility with older versions	3,459	3,515	0,3684	3,636	0,1547	3,200	0,0386

Conclusions

The way people access the Web is changing rapidly. The Web is increasingly used in smartphones, tablets, TVs and other devices. Therefore it is crucial the adoption of a new approach of creating Web pages and making them able to adapt and respond to any device. Responsive design is characterized by ensuring a dynamic adaptation of the contents to the display size, thus ensuring a good viewing experience regardless of the Web access device. Several advantages are associated with responsive design such as high flexibility, a good user experience, low development and maintenance time & costs, improved SEO, a lower bounce rate, increased productivity, and increased accessibility. However, responsive design is not exempt from criticism, and also presents a set of limitations, respectively in the adaptation of contents, difficulties in optimizing user experience, higher loading time, not suitable for complex projects, low availability of CSS media queries and issues in browser compatibility with older versions.

The performed study turns out that software developers emphasize the guarantee of a good user experience and the increase of accessibility as the two most important advantages of responsive design. Additionally, there is greater disagreement in considering time and maintenance costs as an advantage of responsive design. Regarding the limitations, they emphasize the compatibility with older versions of a Web browser, the higher loading time and the difficulties in optimizing user experience. Finally, it should be mentioned that the perception of the advantages and limitations of responsive design is slightly different for professionals with greater years of experience and for freelancers. The professionals with greater professional experience in the sector and in the field of responsive design give less importance to the benefits in terms of the time and costs of development and maintenance, besides mentioning greater difficulties in the process of adaptation of contents; freelancers have the opposite behavior as they give greater importance to maintenance development costs and times, as well as being less sensitive to limitations in the loading time of a website and in compatibility with older web browsers.

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