An Integration of HCI With Accessibility and Usability to Evaluate University Websites

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Abstract: *University Websites give the first impression of their educational organizations, as they represent a broad horizon for the aspects of the universities. Since the information that they provide and the way they have been presented will affect the existing students, staff, and potential candidates who will join the university. This research evaluates the usability and accessibility of university websites using the main Human-Computer Interaction (HCI) principles. This is done by measuring the accessibility, usability guidelines, and HCI principles through two different points of view; first, a humanistic point of view; which is presented using a survey that evaluates the users' opinions. Second, a computer point of view, where the SortSite tool is used to examine each university website. The findings showed that these guidelines still have not been considered seriously, and the tested websites face many violation issues. Moreover, many violations happened because developers did not define User Interface (UI) attributes in the Cascading Style Sheets (CSS) code.*

Keywords: *HCI; Accessibility; Usability; University Websites Evaluation;*

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تكامل مبادئ تفاعل الإنسان والآلة مع مبادئ إمكانية الوصول وسهولة الاستخدام في تقييم مواقع الجامعات

رقية عبد الرحمن

مستخلص البحث: تعطي المواقع الإلكترونية للجامعات الانطباع الأول عن المؤسسة التعليمية وذلك نظرًا لأن المعلومات التي تقدمها وطريقة تقديمها تؤثر على الفئة المستهدفة من الطلاب والموظفين المنتسبين لها وكذلك المرشحين للإنضمام لها مستقبلاً. يهدف هذا البحث إلى تقييم مدى سهولة الاستخدام وقابلية الوصول إلى مواقع الجامعات المختلفة باستخدام مبادئ Human Computer Interaction (HCI) الرئيسية. ويتم ذلك عن طريق قياس مدى إمكانية الوصول وإرشادات الاستخدام ومبادئ أخرى مختلفة من HCI. مع مراعاة القياس من خلال وجهتي نظر مختلفتين ؛ أولاً ، وجهة نظر بشرية ؛ والذي يتم تقييمه باستخدام استبيان يقيم آراء المستخدمين المختصين في مجال الحاسب الآلي. ثانيًا، وجهة نظر حاسوبية ، حيث يتم استخدام أداة SortSite لفحص موقع كل جامعة. أظهرت النتائج أن هذه الإرشادات المعتمدة عالميا لم تؤخذ بطريقة كاملة عند تصميم مواقع الجامعات ، وأن المواقع التي تم اختبارها تواجه العديد من مشكلات الانتهاك لأن مطوري المواقع لم يحددوا سمات واجهة المستخدم في UI attributes in the CSS.

كلمات مفتاحية: تفاعل الإنسان والآلة، إمكانية الوصول؛ سهولة الاستخدام؛ تقييم مواقع الجامعات

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1. Introduction

The website of a university is the first interface and the mirror that should reflect what the university provides for students and communities. Choosing which university to attend is a fateful decision for youth and parents. Thus, building a well-structured website and feeding it with the appropriate content is an important issue that each university needs to pay attention to.

There are so many criteria that should be taken into consideration when building a website. As the target or audience of universities ranged from teenagers to seniors with all different levels of education, culture, ethnics, and tendencies in addition to visual and auditory disabilities for some people. Similarly, a university website should be easy to use and comprehend so that students can search for specific information that should fulfill their decision to attend the university in the first place. Then to updating them for at least four years with the information that will facilitate their journey in higher education level.

This leads to the fact that web accessibility and usability play a solid role in every website design. Web usability and accessibility are closely related to each other because both concepts aim toward the same goal; make a website that works well for everyone. It is effective to address them together when designing and developing a website for users with and without disabilities. However, applying the usability and accessibility guidelines during the web application development process may not guarantee to cover all significant needs and requirements concerning a variety of end-user populations (Moreno, Martínez, and Ruiz-Mezcua 2009). To achieve ultimate results, developers must apply the Human-Computer Interaction (HCI) concept and follow its principles alongside the accessibility guidelines and usability guidelines by integrating them with the Software Development Life Cycle (SDLC) of the website (Stephanidis et al. 1998).

This paper is organized into four main sections; an introduction, and a literature review to present a brief description of accessibility guidelines, usability guidelines, and HCI principles. Then present the applied methodology which has four subsections: choosing and categorizing educational websites, data collection, evaluation survey, and automatic testing tool (SortSite). After that, results are discussed as follows: web accessibility results; most violated Web Content Accessibility Guidelines (WCAG) 2.1 in level A, most violated WCAG 2.1 in level AA, accessibility-related questions in HCI survey), web usability results (evaluation results, usability-related questions in the survey), and finally HCI principles results.

2. Literature Review

2.1. Web Accessibility Guidelines
To design and develop a good website, developers must consider all types of users, whether they have any kind of physical disability or not. Therefore, The World Wide Web Consortium (W3C) has launched the Web Accessibility Initiative (WAI) which has many strategies and standards to help developers in designing their websites (W3C WAI 2021b). WAI is divided into groups each has its standardizations and focuses on a specific area. Some of these groups are Web Content Accessibility Guidelines (WCAG), Authoring Tool Accessibility Guidelines (ATAG), and User Agent Accessibility Guidelines (UAAG) (W3C WAI 2021b, 2021). This paper aims to shed light on WCAG only since it is considered to be the benchmark for website accessibility. Moreover, almost all universities' designers and developers (content authors) primary role is to create or modify content for their organizations while ATAG is designed for the developers of authoring tools such as code editor or WordPress. In shorts, "WCAG improves experiences for end users, while ATAG improves experience for authors" (Bureau of Internet Accessibility 2022)(Smith 2021).

Table 1: WCAG 2.0 Conformance Levels

Level	Key
A	Web pages that have A-level issues are unusable for some people.
AA	Web pages that have AA-level issues are very difficult to use.
AAA	Web pages that have AAA-level issues are For the survey, difficult to use.

WCAG has set four main guidelines to ensure the accessibilities: perceivable (present the information and User Interface (UI) component in a way that could be realized by users), operable (to keep the UI components in reliable functioning conditions), understandable (the components can be easily read and predict by the user) and robust (website is compatible and can rely on with different types of web browsers and screen readers) (W3C WAI 2021). Each of these categories falls into three levels of conformance to meet the needs of different groups and different situations: A(lowest), AA, and AAA (highest) Level. Each level contains all its requirements and the requirements related to the previous levels (Akgul 2017; W3C WAI 2021a). Table 1 summarizes these success criteria levels and their meanings.

There are many studies concerning evaluating the web accessibility of university websites using different automatic tools that measure WCAG guidelines. For example, the researchers in (Macakoğlu, Peker, and Medeni 2023) evaluated the prospective students' web pages of 330 universities; the top ten of 33 countries distributed in Europe, North America, and Oceania based on Webometrics Ranking of World Universities. The study used an automatic evaluation tool called TAW for web accessibility analysis. It found that 312 university websites did not meet the compliance level AA of WCAG 2.0 accessibility. Also, the highest error rate was in the robust principle (about 45%), while the lowest error rate with 5% was found in the understandable principle.

In the case of Turkish universities, the researchers measured the WCAG 1.0 which consists of 14 guidelines or checkpoints by using an evaluator called AChecker. The results showed that all 23 university websites violated the WCAG 1.0 checkpoints and did not reach an acceptable level of conformance (Akgul 2017). In terms of WCAG 2.0, a study was conducted to evaluate the accessibility of more than 300 homepages of Indian universities' websites and classified them into three categories based on their conformance levels of WCAG 2.0 violations to enhance the accessibility, the researchers used various evaluation tools which are AChecker, webpage Analyzer, and WAVE (Ismail and Kuppusamy 2018).

Furthermore, Saudi university websites also suffer from the lack of accessibility standards and fail to achieve the lowest conformance based on the findings from a research study that evaluated 25 Saudi universities' websites using JAWS and Supernova tools (Fakrudeen, Rana, and Rana 2011). These studies and many others reflect not only that accessibility is a cornerstone of any website, but also reveal the lack of implementation of accessibility standards and guidelines in web application development.

2.2. Web Usability Guidelines
A website is called usable when it enables the user to accomplish tasks in an efficient, effective, and satisfying way. Usability is extremely essential in developing a website since the end user's perception is the main factor that defines how successful the website will be (Matera, Rizzo, and Carughi 2006). It can be done by making the users and their needs the focus when designing the website, and it is called User-Centered Design (UCD). This method not only facilitates achieving the usability goals but also ensures that all

requirements and functions of a website can be delivered in a highly usable way (Monk 2000). Considering that, the U.S. Department of Health and Human Services (HHS) has set several usability guidelines that offer a clear roadmap for systems analysts and developers to follow to implement highly responsive and easy-to-use websites (United States. Department of Health and Human Services. and United States. General Services Administration. 2006).

Regarding the usability evaluation literature using two automatic evaluation tools (Bobby and LIFT), a study on 11 Malaysian public universities showed that almost all tested websites scored a low point in terms of usability. Further results discovered that many tested websites must improve their navigation usability such as search, sitemap, and Index features (Junaini 2002). Measuring the internal attributes of a website gives a piece of clear evidence about the usability of that website, for example, testing download time, size of HyperText Markup Language (HTML) webpage, ...etc. By using the HTML toolbox and web page analyzer online testing tool, 20 university websites in Bangladesh were tested by measuring the quality of their internal features. The findings have identified the weak points of some usability aspects such as interface design and performance for these websites (Islam and Tsuji 2011). Thus a recent research done by (Campoverde-Molina, Luján-Mora, and Valverde 2023) proposing a framework for evaluating the usability of academic websites through providing an evaluation tool in order to: help the developers of universities' websites to diagnose weak usability areas of their web sites to be improved, and to understand the keys ability criteria to be taken in consideration during designing face.

2.3. HCI Principles

HCI is a field of study focusing on the design and use of computer technology and its interactions with users (Ho et al. 2009). HCI concerns about how people interact with the UIs in terms of physical elements on the UI such as buttons,

screens, and menus, and in terms of the logic of the UIs which the system model and the set of available tasks (Metzker and Reiterer 2002).

To understand HCI deeply, there are some aspects or principles in which HCI can be implemented correctly. These principles differ according to researchers' perspectives. Although they agree that these HCI principles are focused on non-functionality requirements analysis of software development. However, some researchers stated that HCI concerns consist of four major areas, which are physical concern (ergonomic), cognitive concern (usability), affective, Emotional Intrinsically motivational concern (pleasing and enjoyable), and extrinsically motivational concern (usefulness) (Majid et al. 2009). While others described in detail twelve principles for good human-centered design, which are visibility, consistency, familiarity, affordance, navigation, control, feedback, recovery, constraints, flexibility, style, and conviviality (Hussain Imran n.d.).

Exploring various principles of applying the HCI concept introduces us to a broad set of methods for evaluating website effectiveness. Moreover, integrating HCI principles with WCAG accessibility and usability.gov[1] guidelines for evaluating university websites will enhance the analysis process and provides more accurate results.

3. Methodology

3.1. Choosing And Categorizing Educational Websites

Choosing which university website to evaluate has been complicated since there is no formal organization that categorizes and ranks universities based on their websites. However, one of the criteria for categorizing universities in the rank resources such as Shanghai Ranking is the website design but with no formal documentation about it (ShanghaiRanking 2020).

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[1] https://www.usability.gov

Table 2: Top Five Global Universities Based on The Rank Resources

University Code	Shanghai Ranking	Top Universities	Times Higher Education	USNews
G1	9	5	2	6
G2	1	3	7	1
G3	4	1	5	2
G4	2	2	4	3
G5	7	4	1	5

Table 3: Top Five Arabic Universities Based on The Rank Resources

University Code	Top Universities	Times Higher Education	USNews
A1	5	3	9
A2	2	6	5
A3	11	17	4
A4	13	33	7
A5	9	-	19

Table 4: Top Five Saudi Universities Based on The Rank Resources

University Code	Shanghai Ranking	Webometrics	UniRank	USNews
S1	1	2	2	1
S2	2	1	1	3
S3	3	3	13	2
S4	4	4	6	4
S5	-	9	12	5

Based on multiple ranking resources, we looked for the top universities and categorized them into three categories which are best global universities, best Arabic universities, and best Saudi universities. These ranking resources are Shanghai Ranking (ShanghaiRanking 2020), TopUniversities (Quacquarelli Symonds n.d.), TimesHigherEducation (Times Higher Education 2020), and USNews (Morse 2021), each of which has different ranking criteria and metrics.

We found out the top ten global universities in each resource and chose the five common ones across them. For data confidentiality, universities' names were omitted and have been given codes instead. Table 2 shows the top five global universities and their rank number by each resource. Table 3 shows five Arabic universities that have been chosen for evaluation based on the top 50 in the Middle East region. It should be noted that the Saudi universities were extracted from this category since there is a category specified for Saudi universities. The last category is the Saudi Universities as shown in Table 4. Another two ranking resources have been added, which are Webometrics (Cybermetrics Lab 2020) and UniRank (UniRank 2020).

3.2. Data Collection

The research consists of two main methods for data collection which are the responses of an evaluation survey and the result of an automatic evaluation tool. For the survey, data was collected during the beginning of academic years 2020 and 2023. The sample of the study contained 157 evaluators who were Computer Science students at different levels, Computer Science faculty members from different universities, Information Technology employees and users with limited knowledge of web design criteria.

3.3. Evaluation Survey

An evaluation survey helps in gathering data about what the users need and what problems they face. Also, it helps to understand the gap between website requirements and users' needs (Preece 1994). Before conducting a survey, various types of evaluation techniques should be considered, and then apply the most appropriate for the case. One of these techniques is heuristic evaluation (Villiers 2000).

In a heuristic evaluation, evaluators use a set of guidelines (or heuristics) to examine and critique software and help to identify issues in the user interface design that might damage the user experience (Villiers 2000). The method includes ten heuristics that can be used to evaluate HCI usability in a website. These are visibility of system status, recognition rather than recall, flexibility and efficiency of use, user control and freedom, the match between system and the real world, consistency and standards, error prevention, aesthetic and minimalist design, help functions, and help users recognize, diagnose and recover from errors (Nielsen and Molich 1990). Of course, researchers can add more heuristics or remove some of them to fit their requirements of the evaluation (Nielsen 1994).

In the case of this study, heuristic evaluation is conducted to evaluate usability and accessibility in HCI. This is done by developing a survey using a questionnaire that has a set of questions based on HCI-selected heuristics. These are visibility, navigation, feedback, trustworthiness, personalization, visual aesthetics, learnability, efficiency, quality of content, and usability.

Regarding accessibility, as stated earlier WCAG consists of four main factors hence the accessibility of a web can be measured using these characteristics as evaluation factors which are perceivable, operable, understandable, and robust. Similarly, there are principles in HCI that mirror these WCAG factors. For that, some of the questions in the survey target the user's point of view in terms of both accessibility and HCI. Equivalently, Usability and HCI have similar guidelines that can be evaluated using the same questions. Table 5 shows these questions and related factors in terms of HCI, accessibility, and/or usability. It must be clarified that the answer to each question consists of a scale starting from 1 (the least satisfied) to 5 (the highest).

Table 5: Survey Questions with The Related Guidelines of HCI, Accessibility, and Usability

Question	Heuristics (guidelines)
1. The links, categories and functions of the website are: Visible?	**HCI:** Visibility **Accessibility:** perceivable
2. The navigation between the website pages are: Flexible?	**HCI:** Navigation **Accessibility:** operable
3. In my opinion, the information and data provided by the website are: Well prepared?	**HCI:** Quality of Content **Accessibility:** understandable
4. Regarding my personal requirements and preferences such as language, the website is: Adjustable?	**HCI:** Personalization **Accessibility:** robust
5. I consider the website feedbacks to my actions as: Consistent?	**HCI:** Feedback
6. Regarding the use of my personal information and data, the website is: Trustworthy?	**HCI:** Trustworthiness
7. In my opinion, the visual design of the website is: Stylish?	**HCI:** Visual Aesthetics
8. The website and its structure are: Easy to learn?	**HCI**+ **Usability:** learnability

9. The overall website performance is: Efficient?	**HCI + Usability:** efficiency
10. I consider the possibility of using the website as: Useful?	**HCI + Usability:** usability

3.4. Automatic Testing Tool (SortSite)

There are many evaluation tools on the internet that have a variety of features and rules to check website accessibility and usability. Bobby and WebX-Act are largely used and the most well-known tools for evaluation. However, they do not provide full coverage of WCAG testing and both give fairly accurate results which affect the quality of the analysis process and its outcomes (Luque Centeno et al. 2006). To have more accurate analysis and reliable results, it is necessary to search for a tool that checks against all WCAG and focuses on covering the entire site when testing, such as the SortSite tool.

SortSite is a testing tool used by many federal organizations, developers, and researchers to check against the accessibility and usability of a website. It evaluates and checks whether a website is complying with WCAG 2.0, WCAG 2.1, and Section 508 accessibility guidelines. Also, it concerns the usability of the website and checks it against Usability.gov guidelines. It is one of the powerful evaluation tools because it does not only test the homepage but also tests all pages it can find on a website. On top of that, SortSite is considered as an advanced checker and validator since it checks against broken links, browser code compatibility, search engine optimization, and many other issues (WebAble 2021).

The 15 university websites were checked and tested using the SortSite tool with the primary focus on accessibility and usability issues that violate the guidelines. All extracted data from SortSite were gathered and organized into Excel sheets to analyze them and provide accurate and useful results.

4. Results And Discussion

The results of the accessibility and usability test will be presented, both according to the SortSite tool and the questionnaire. Next, the results of the evaluation of the remaining HCI Principles in the questionnaire will be presented at the end of the section.

4.1. Web Accessibility Results

A website is considered to have an access issue when it causes a relatively bigger problem for people with disabilities than it causes for people without disabilities. SortSite testing accessibility by indicating all issues and problems for older users and/or people with disabilities or accessibility needs to be based on references to WCAG.

Table 6 describes the results for the three main categories which are Saudi, Arabic, and Global universities. The total number of pages and files analyzed by the tool is 7409 ranging from 300 to 530 for each university website.

As an overview, it can be seen from the table that all the tested websites have lack web accessibility on many pages. Moreover, none of the tested websites have passed the first accessibility level of conformance which means these web pages are considered unusable for some people. Also, the tested websites have some pages that are very difficult to use since they did not pass the level AA of conformance.

When comparing university websites on the level of their categories they fall in, we can say that most global universities have a percentage that is relatively low accessibility issues while Saudi and Arabic universities face a large number of accessibility violations on their websites. However, only one Saudi university stands out from its category and competes with global universities in the high level of web accessibility, which is S2.

Table 6: The Results of The Accessibility Evaluation for Websites of The Three Main Categories

(SortSite automatic analyzer tool results)							
Main Category	Uni Code	Pages Analyzed	pages have Accessibility Issues	Level A		Level AA	
				Issues	Pages	Issues	Pages
Saudi	S1	520	26 %	33	126	4	83
	S2	311	6 %	20	16	4	16
	S3	525	48 %	24	248	4	244
	S4	520	47 %	39	234	5	101
	S5	528	51 %	43	265	2	55
Arabic	A1	528	43 %	35	223	7	218
	A2	487	50 %	39	242	6	238
	A3	437	42 %	25	177	6	70
	A4	530	33 %	27	167	3	91
	A5	525	30 %	27	156	5	105
Global	G1	508	20 %	23	100	4	84
	G2	504	13 %	11	62	3	16
	G3	495	9 %	10	42	4	35
	G4	476	6 %	5	27	2	22
	G5	515	54 %	16	277	5	71

The violations are not limited to a few pages of university websites, but on a large scale as seen from the number of web pages in the above table. Moreover, these issues are classified according to the principles that have been violated, and the SortSite tool tests against the ones found in the first and second levels of conformance.

4.1.1. Most Violated WCAG 2.1 in Level A
The minimum level of conformance in web accessibility provides the most basic web accessibility features that a website must deliver, otherwise, it would be very difficult or impossible for people with disabilities to access information on the web pages.
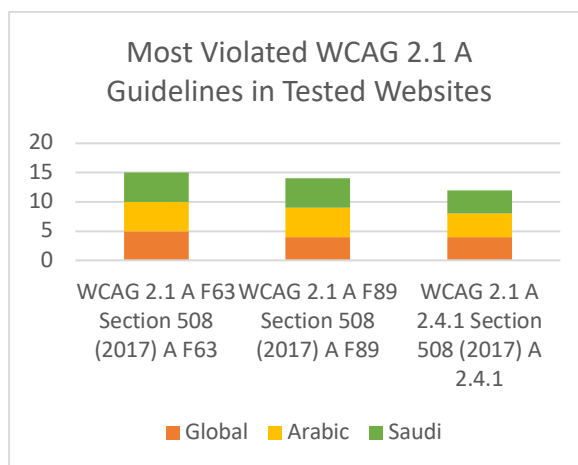

Fig. 1: Most Violated WCAG 2.1 A Guidelines in Tested Websites

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Table 7: Description of The Most Violated WCAG 2.1 A Guidelines in Tested Websites

Guideline	Description
WCAG 2.1 A F63 Section 508 (2017) A F63	Several links on a page share the same link text and surrounding context but go to different destinations.
WCAG 2.1 A F89 Section 508 (2017) A F89	Each 'a' element must contain text or an 'img' with an 'alt' attribute.
WCAG 2.1 A 2.4.1 Section 508 (2017) A 2.4.1	iframe and frame elements must have a 'title' attribute.

According to the above table, a significant number of accessibility issues appeared at this level on every university website. Although the number of these issues is within a specific range, the principles that were violated varied greatly from one university website to another.

Nevertheless, the three most frequently violated guidelines in the tested websites were found, and Figure 1 illustrates them. Descriptions of these guidelines are shown in Table 7 and discussed in detail in the next paragraph.

WCAG 2.1 A F63 Section 508 (2017) A F63 is a guideline that concerns the location of links in the context of the text. Some web pages may contain links outside the context of the sentence, paragraph, or preceding heading which may mislead the user (or screen reader) about the purpose of the link (W3C 2016a). From the above chart, it is clear that this guideline has been violated by all university websites falling into all categories. Likewise, for the second violated guideline, WCAG 2.1 A F89 Section 508 (2017) A F89 is violated when there is a link that contains non-text content such as images or the `alt` text is blank then the link cannot be accessible. Thus, assistive technology as a screen reader would read out the Uniform Resource Locator (URL) instead (W3C 2016c).

Last but not least is WCAG 2.1 A 2.4.1 Section 508 (2017) A 2.4. A guideline stating that every frame element on a website page must be titled or labeled using 'title' attribute or ARIA label so the screen readers would not read out meaningless frame title such as 'frame zero' (W3C 2023b) and then confuse the users.
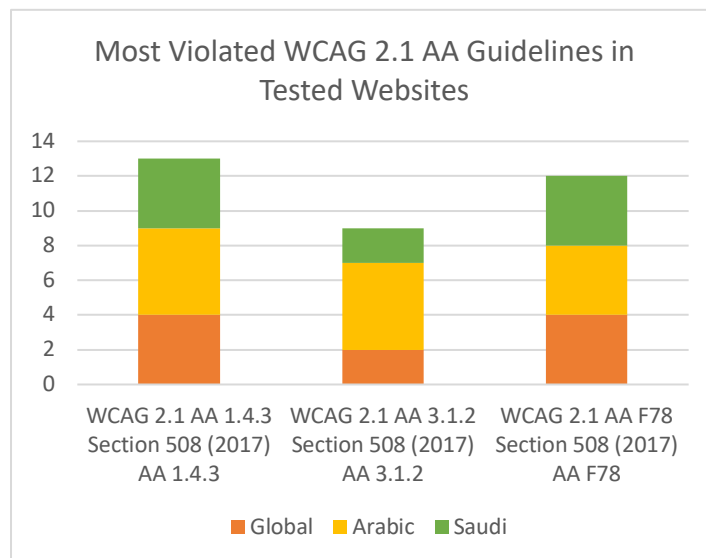

Fig. 2: Most Violated WCAG 2.1 AA Guidelines in Tested Websites

Table 8: Description of The Most Violated WCAG 2.1 AA Guidelines in Tested Websites.

Guideline	Description
WCAG 2.1 AA 1.4.3 Section 508 (2017) AA 1.4.3	Ensure that text and background colors have enough contrast.
WCAG 2.1 AA 3.1.2 Section 508 (2017) AA 3.1.2	Phrases in a different language should be in a span or div with a 'lang' attribute.
WCAG 2.1 AA F78 Section 508 (2017) AA F78	The CSS outline or border style on this element makes it difficult or impossible to see the dotted link focus outline.

4.1.2. Most Violated WCAG 2.1 in Level AA

On another level, if a website meets WCAG 2.0 Level AA conformance then it is considered to be usable and understandable by a broad range of different users. SortSite has revealed all the issues that resulted from violating the WCAG 2.1 AA in tested websites. Figure 2 presents the most violated guidelines according to their number of presence in each category. Descriptions of these guidelines are shown in Table 8 and will be presented and discussed in detail in the next section.

One of the most important elements in any web page is the text and its background - WCAG 2.1 AA 1.4.3 Section 508 (2017) AA 1.4.3. Providing enough contrast between them makes it more readable to different types of users such as people with and without color deficiencies. This guideline recommends using a contrast ratio of at least 4.5:1 (W3C 2023a). However, all Arabic universities and many Global and Saudi have failed to meet the success criterion for this guideline in their websites.

Similarly, the WCAG 2.1 AA 3.1.2 Section 508 (2017) AA 3.1.2 guideline has been violated by all of the tested Arabic university websites which relate primarily to the use of a non-English language on these sites. When a website uses a non-English language, it must be identified the used language with a 'lang' attribute so the assistive technologies and conventional user agents can read and present content correctly. This guideline is very important, especially in the case of languages that read from right to left such as Arabic language (W3C 2023c).

The last principle that was widely violated in all categories is WCAG 2.1 AA F78 Section 508 (2017) AA F78, as it was violated in 4 out of 5 university websites in each category. This guideline is particularly concerned with keyboard-only users, as it relies on the focus indicator feature. However, a CSS a border or outline styling may obscure the focus indicator on links, buttons, or dropdowns in a web page such as using outlines that look like the focus outline or bold borders that have the same color as the focus indicator (W3C 2016b).

4.1.3. Accessibility-Related Questions in HCI Survey

HCI has several guidelines that can be examined by accessibility characteristics, which are (Visibility must be perceivable), (Navigation must be operable), (quality of content must be understandable), and (Personalization must be adjustable). Figure 3 illustrates the results of accessibility-related questions from the conducted survey.

Most of the results were relatively satisfactory, it showed that more than half of respondents were satisfied with the level of quality of the information provided to them in the websites at all categories, as well as the navigation feature. The Saudi category outperformed the other categories in terms of personalization because half of the respondents found the websites were adjustable for their requirements and preferences. In the case of the visibility principle, only global websites showed a relatively positive outcome since more than half of the respondents were satisfied with it.
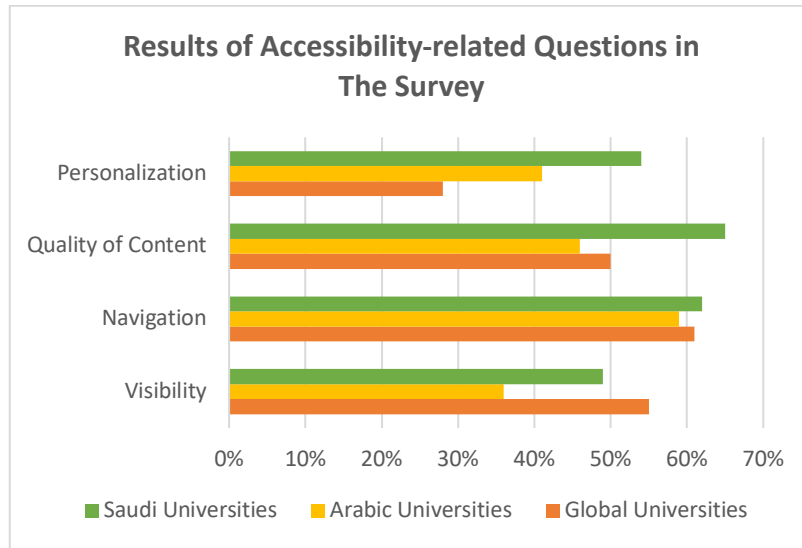
Fig. 3: The Results of Accessibility-related Questions in The Survey

It can be concluded that both points of view agreed on the same outcome. The results of the SortSite tool analysis showed a lack of commitment to accessibility guidelines in all three categories as well as the respondent's feedback as we reviewed earlier. Moreover, the validity of the results can be affirmed as the guidelines of accessibility focus on designing UI elements such as links and buttons efficiently and effectively which has been violated. Therefore, users expressed how difficult it is to use these websites due to the inefficient UI and code flaws. For that, it is necessary to define attributes in the CSS code such as 'alt', 'title', and 'lang' attributes.

4.2. Web Usability Results

SortSite tool examines the usability of university websites by indicating navigation problems for all users. It shows which pages violate the guidelines stated in Usability.gov Guidelines and W3C Best Practice.

Table 9: The Results of The Usability Evaluation for Websites of The Three Main Categories

(SortSite Automatic analyzer tool results)							
Main Category	Uni Code	Pages Analyzed	Pages with Usability Issues	Issues			Total Issues
				Priority 1	Priority 2	Priority 3	
Saudi	S1	520	24 %	2:94	13:113	6:41	73
	S2	311	6 %	1:9	6:14	1:4	
	S3	525	47 %	1:9	7:242	4:70	
	S4	520	48 %	2:80	11:237	6:56	
	S5	528	47 %	1:2	8:237	4:72	
Arabic	A1	528	42 %	1:34	8:218	6:48	71
	A2	487	46 %	2:236	7:237	5:62	
	A3	437	37 %	2:81	9:118	4:63	
	A4	530	35 %	1:7	5:166	4:71	
	A5	525	27 %	2:23	11:133	4:86	

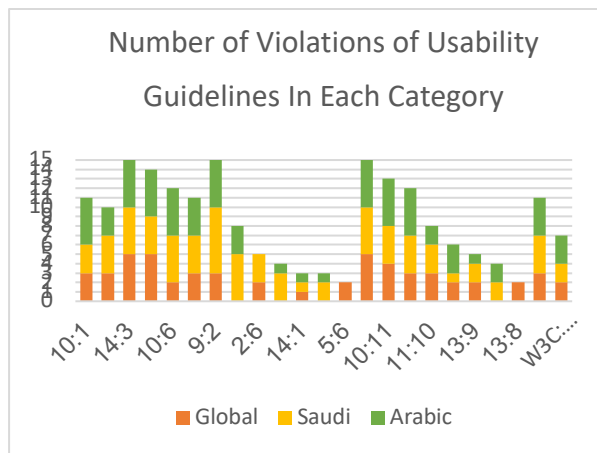|							
	G1	508	19 %	2:32	7:94	5:22	
	G2	504	12 %	2:57	4:29	5:12	
Global	G3	495	7 %	1:11	5:26	2:8	55
	G4	476	6 %	-	3:5	2:27	
	G5	515	49 %	1:16	9:102	7:193	

Fig. 4: Number of Violations of Usability Guidelines in Each Category

4.2.1. Usability Evaluation Results

Table 9 presents the usability evaluation results of the 15 university websites. The total number of pages tested is 7409 ranging from 300 to 500 pages per website.

The tool uses classifications and priorities of issues according to their impact. It gives issues with higher impact priority, and so on. It represents these priorities as an ordered pair of the number of issues per number of web pages (#issues: #webpages).

As shown in the table, none of the 15 websites are completely free from usability violation but they differ in the percentage of this violation. In general, the results of the Saudi universities category are similar to the Arab universities, as the tool showed that most websites in both categories suffer from many different usability issues by a rate that almost reaches 50%. Meanwhile, the category of global universities was better due to the lower percentage of usability problems that the websites have. This gives us clear evidence that global universities focus mainly on Usability.gov guidelines and W3C principles when designing and developing their websites, while most Arabic and Saudi universities have neglected some of these principles. This may

lead to mislead the users and be incapable of browsing smoothly and clearly.

Moreover, as can be noted from the table in the first category, the S2 university has a very slight percent issue in its web pages (6%). It is apparent that S2 has a website of high quality and can be placed at the top of the list with global universities such as G3(7%) and G3(6%).

To get a comprehensive view, Figure 4 shows all the guidelines that were violated by the tested websites based on their category. Descriptions of these guidelines are shown in Table 10 and will be presented and discussed in detail in the next section.

In general, as shown in the chart above, usability guidelines 14:3, 9:2, 11:8, 10:4, and 10:11 are the most violated guidelines in all websites that focus on different aspects of usability. For instance, all 15 tested websites violated the basic principle in designing a web page layout which is; each image should have defined width and height attributes as described in the Usability.gov 14:3 guideline. By neglecting them the page can take too much time to load. For instance, Figure 5 represents a CSS code of this issue, this can be fixed by adding this CSS statement to the code: 'img' {max-width: 100%; height: auto}.

```
<img alt="Table" src="https://public.tableau.com/static/images/No/NorringtonPublic/Table/1_rss.png style="border: none" />
```

Fig. 5: A CSS Code of An Image Without Defining Width and Height Attributes

Table 10: Descriptions of Usability.gov And W3C Guidelines

Priority	Guideline	Description
1	10:1	"Users should be able to quickly look at each link and tell where it goes."
1	5:1	"Have a link labeled 'Home' on every page on the site, except for the home page."
2	14:3	"Omitting 'imag' width or height attributes makes the page layout jump about as images load."
2	10:4	"Avoid underlined text - people will click on it and think it's a broken link."
2	10:6	"Use text links rather than image links. In general, text links are more easily recognized as clickable."
2	13:5	"Use label elements for each data entry field to show what data is expected."
2	9:2	1- "This page title is not unique. Each page should have a descriptive and meaningfully different title." 2- "This page has no title. Each page should have a descriptive and meaningfully different title." 3- "This page has a default title like 'Untitled' or 'Title'. Each page should have a descriptive and meaningfully different title."
2	17:4	"Provide a search option on each page of content-rich web sites."
2	2:6	"Minimize the time required to download a Web site's pages."
2	7:1	"Do not create or direct users into pages that have no navigational options. No links out of these pages found."
2	14:1	"Use background images sparingly and make sure they are simple, especially behind text."
2	10:7	"Use color changes to indicate to users when a link has been visited. This page sets identical colors for visited and unvisited links."
2	5:6	"An active 'Home' link on the home page makes some users think that it's not the home page."
3	11:8	"Use at least a 12-point font on all web pages."
3	10:11	"Use link text between 3 and 100 characters so it's long enough to be understood but avoids line wrapping."
3	11:5	"Use bold text sparingly - for one or two words or a short phrase."
3	11:10	"Use italic text sparingly - for one or two words or a short phrase."
3	13:12	"Use option groups when a drop-down list has more than 10 items."

3	13:9	"Radio buttons are easier to use than drop-downs when there are 6 choices or fewer."
3	11:7	"Use a familiar font (Times, Georgia, Arial, Helvetica or Verdana) to achieve the best possible reading speed."
3	13:8	"Create data entry fields that are large enough to show all of the entered data without scrolling. One study has shown that search fields should be at least 35-40 characters long to accommodate 95% percent of search terms."
2	W3C: URLs	"Keep URLs shorter than 78 characters so they don't wrap when emailed."
2	W3C: images	"The 'imag' width and height attributes don't match the actual image size. This means the image will be distorted or resize during loading."
1	5:1	"Have a link labeled 'Home' on every page on the site, except for the home page."
2	14:3	"Omitting 'imag' width or height attributes makes the page layout jump about as images load."

Another important aspect of usability is the page title, each webpage should have a unique descriptive title and that is what Usability gov. 9:2 states. Nevertheless, all websites in all three categories did not pay much attention to naming their web pages properly.

Some violated guidelines have appeared in one category and not in others, such as the 17:4 guideline - which has been in all Saudi universities and three Arabic ones- and 13:8 guideline – which only appeared in the global category. Both of these guidelines are related to search designing criteria.

It can be noticed from Figure 4 and Table 10 that the most commonly violated guidelines are related either to the links (Buttons) and/or the text and its properties. Take the guidelines in the first-priority section, for instance, both of them focus on how the buttons and links should appear to the user. Usability.gov 10:1 guideline has been violated 11 times, which states that "Users should be able to quickly look at each link and tell where it goes". However, many web pages use generic link labels like "click here" or "find more" and that can sometimes be misguided for some users. Moreover, 10 websites out of 15 had issues related to missing out on having a "Home" button on every page on the site, which broke what Usability.gov 5:1 guideline states.

On the other hand, two global universities have done the opposite by placing the "Home" button on the home page which violates principle 5:6. Furthermore, there are guidelines in the second priority that also focus on how links should appear to the users in a way that looks familiar and clickable. These are Usability .gov 10:4 and 10:6 guidelines, which have been violated by 14 and 12 tested websites, respectively. Guideline 10:4 states that it is preferable not to use an underlined text since using it in web pages can be understood as a hyperlink. While guideline10:6 states that the link must be in the form of a text and not as an image since most users are familiar with the text link. Similarly, in the third-priority, guidelines 11:8, 10:11, 11:5, 11:10, and 11:7 also concern about text properties - see their descriptions in Table 10 - this indicates that the most important element of any webpage is the text, which plays an essential role not only in the Usability field but also in the HCI field.

4.2.2. Usability-Related Questions in The Survey

Similar to accessibility, several guidelines are common between HCI and usability, which are efficiency, learnability, and of course usability itself. Figure 6 illustrates the results of usability-related questions from the conducted survey.
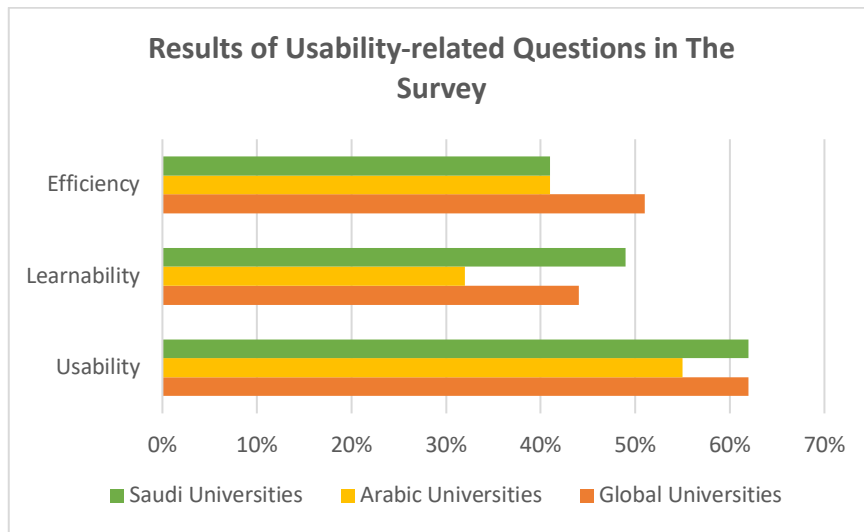
Fig. 6: The Result of Usability-related Questions in The Survey

Overall, the results are similar to those of the accessibility-related questions in the survey; both are relatively satisfactory. More than a half consider the use of the websites to be completely useful. While less than half of them considered the websites to be understandable and efficient.

Although a good percent of the end-users did not encounter (or did not feel) these problems, it is important to consider the remaining others.

To sum up, these findings lead us to the same conclusion, to have a usable and accessible website, developers must take into consideration the standard guidelines when designing UI elements.

4.2.3. HCI Principles Results

After discussing and analyzing the common HCI principles with both accessibility and usability, it remains only those that fall under HCI only. These are illustrated in Figure 7 along with the results of the related questions from the conducted survey.
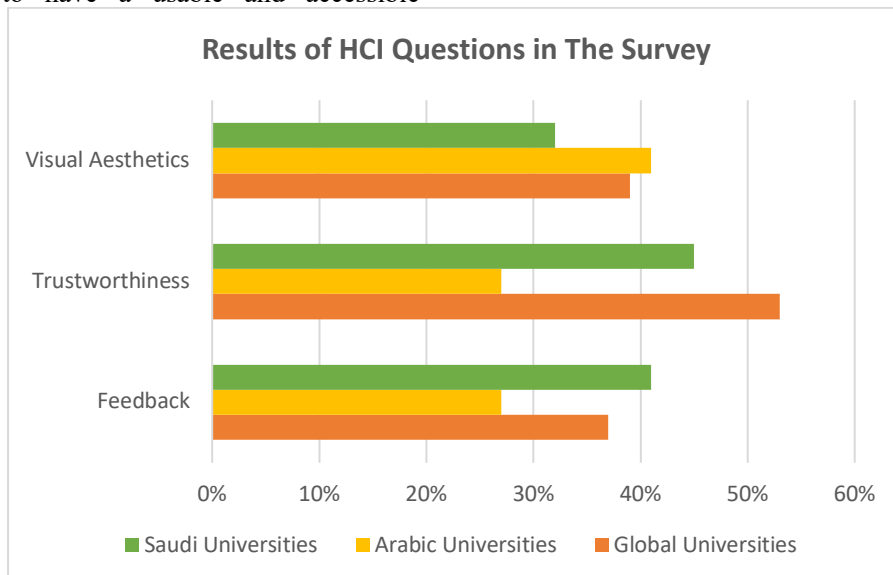

Fig. 7: The Results of HCI Questions in The Survey

From the first glance at the graph, it can be seen that all the categories showed low scores in terms of the HCI principles. The majority of respondents are not satisfied with visual aesthetics nor the website's feedback. However, global university websites showed that they are trustworthy in keeping data secured and saved.

Through the personal observation and discussions of the author with some of the universities' developers (all Saudis due to difficulties and time limitations in contacting with Arabic and Global universities), it could be concluded that the developers did not pay enough attention to the guidelines when designing the websites. They did not use any of the available online free tools to help them improve the websites' designs due to several reasons: the time limitation to submit the tasks, the current website is built to fulfill the need of the leaders of the universities sectors whom most of them have no or extremely limited clue about designing principles, the priorities are paid to the website's contents and how to make it attractive and stylish regardless of how much it is accessible or useable to different types of users.

These findings have raised concerns about the ability of university websites to serve different types of users and the need for following accessibility and usability guidelines in designing websites has increased.

5. Conclusion

Given the standard guidelines and principles to design and develop robust and reliable websites, universities still have not considered them seriously, and their websites face many violation issues. Thus, it affects not only the students but also faculty members and other users with and without disabilities. This study shed light on which kinds of HCI, usability, and accessibility guidelines have been violated by a variety of university websites that have been chosen based on several ranking resources. By using the SortSite tool, each website has been analyzed and checked against many standards-based checkpoints. Besides that, a survey has been conducted on a sample to analyze these websites from a human point of view.

The findings can be summarized as that tested websites in the global category have the best scores regarding their accessibility and usability. However, only one university in the Saudi category competes with them at some level. Moreover, the standards of HCI and the guidelines of accessibility and usability focus on designing UI elements such as links and buttons efficiently and effectively which has been violated. Therefore, developers must pay attention to defining attributes in the CSS code such as 'alt', 'title', and 'lang' attributes. On top of that, universities must give a high priority to follow and apply these guidelines in the development life cycle of their websites and update their guidelines taking into consideration environments, trends, and changes.

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