Improving accessibility of web accessibility rules

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Accessibility is still an open issue since, despite the increasing attention at a legislative, academic, and social level, a wide range of sites are still not able to meet the minimum level of accessibility requirements. For this reason, we implemented MyWcag4All, a website that tries to foster accessibility culture allowing developers to track a site's accessibility at all stages of its development and providing access to a set of useful information like accessibility tests, testing tools, and official guidelines. Moreover, it contains gamification elements to increase the engagement of users in passing all the accessibility tests.

1 INTRODUCTION

Nowadays, web accessibility is an important issue to recognize the right of people with disabilities. But, it also represents a complex challenge: on the one hand, the legislation, especially in Europe, defines clear and strong rules and expands its application area [10, 12, 25]; on the other, web developers lack a proper culture to develop and web accessibility.

The European Disability Strategy 2010-2020 [11] states that web accessibility was one of the most successful achieved goals. This result was due to the approval of the Web Accessibility Directive [12], which set a technical and a legal framework and imposed the accessibility requirements to all the EU public administration websites and mobile apps, and to the following European Accessibility Act [16], which expanded the minimum accessibility requirements to other subjects, like transport or banking, and to all the companies with an annual revenue greater than 500 million euros.

But this important result can be misleading since the concrete situation is far from being promising: according to the last WebAIM report on the top one million pages[41], the number of pages that had a failure during Web Content Accessibility Guidelines (WCAG) [40] tests was 96.8%, which is a little better than the previous year but still an enormous number. Narrowing the focus on the EU states that presented the monitoring report about the periodic monitoring, the first three according to the size of population, Germany, Spain and Italy, shown a difficult situation.

The simplified monitoring carried on in Germany [6], regulated by Commission Implementing Decision (EU) 2018/1524 [15], whose purpose is to verify the non-compliance with the EU standards, highlighted that, among 1,762 public analyzed websites, the "Non text content" criterion of the Harmonized European Standard about "Accessibility requirements for ICT products and services" (EN 301-549) [10], that refers to 1.1.1 criteria of the last W3C recommended

WCAG version [39], were not respected on the 28.5% of cases. In addition, the Spanish report [32] found out that 51.88% of the 1,010 analyzed websites, are not accessible, i.e., they do not reach the WCAG A level nor the AA level, which are mandatory. Even in Italy, a pioneer in web accessibility legislation [17], the first Agency for Digital Italy (AgID) report [1] discovered that, among the 1,297 considered websites, a total of 227,886 errors were found, almost all ascribable to the 9.1.3.1 standard, which references the WCAG 2.1 Info and Relationship criteria whose purpose is to ensure that information and relationships that are implied by visual or auditory formatting are preserved when the presentation format changes[1].

It is therefore clear that, despite the advanced legislation and legal constraints, accessibility struggles to spread in both the public and private sectors. To investigate which is the reason for this inconsistency we have created a questionnaire distributed about web developers. We obtained 53 answers, 88.7% of the participants are males and 11.3% are females. 47% of participants got a degree in computer science or engineering. Most of the participants have some knowledge about accessibility since 94.3% declared to have already heard some information about this theme (and they also confirm their expertise by answering correctly some true/false questions about accessibility).

Nobody declared that having accessibility skills is not important, 11.32% declared that it is less important, and more than 69% declared that it is important or very important to have accessibility skills as depicted in Figure 1. But, when we asked the participants to evaluate their level of expertise, less than 2% declared a high level of expertise and 15.09% declare to be expert (13.21% declared no expertise, 33.96% declared little expertise, see Figure 2).
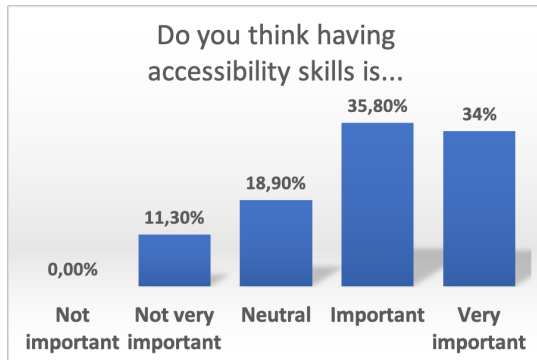

Fig. 1. Answer to the question "Do you think having accessibility skills is...".
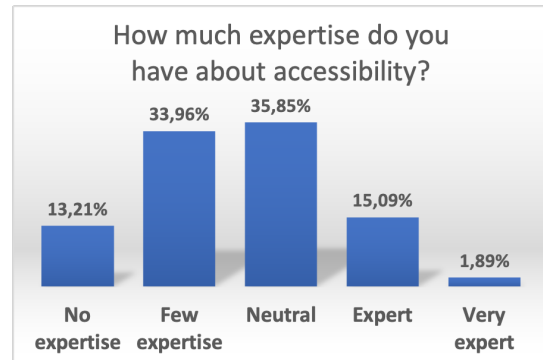

Fig. 2. Answer to the question "How much expertise do you have about accessibility?".

Therefore, even if developers consider it important to have these skills, they don't have them, and so one of the main reasons for the large number of failures in passing the WCAG tests can be considered the lack of knowledge about accessibility among developers.

In this paper, we present *MyWcag4All*, a web application with one purpose: to help the web developers to understand which tests are applied to their websites and which testing tools can be used. In other words, we aim at making accessibility rules and tools more accessible.

MyWcag4All extends our previous work *WCAG4All* [17], a website that contains the complete list of WCAG criteria and possible tools for testing, in particular on two aspects. First, it expands the WCag4All test suite, integrating the newer criteria introduced by the current Working Draft of Wcag 2.2 [40], and second, it adds interactivity to the

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[1]https://www.w3.org/WAI/WCAG21/Understanding/info-and-relationships.html

previous test suite, also adding gamification elements to encourage developers to improve accessibility level of their websites. Now the tool can be used during the entire development process, and so it can be considered de facto a tool for monitoring the status of the accessibility of the site.

Moreover, MyWcag4All creates an information repository regarding accessibility: starting from the consultation of the tests, the false myths and stereotypes, and the tools' sections, we want to provide an integrated and complete tool to spread the culture of accessibility.

2 THE ITALIAN SITUATION

MyWcag4All is strongly based on WCAG and on the Italian "*Guidelines for the accessibility of IT tools*" [2] defined by AGID, where the technical reference lists all the success criteria of A and AA levels of the WCAG 2.1. Therefore we provide in this section a more detailed analysis of the Italian situation, in particular in our province.

We analyzed 102 sites, taken from the official websites of municipalities of the administrative province of Padua. The analysis focused on three main aspects, which, even if they are not technical, denote the care and attention that local public administrations have towards accessibility.

The first aspect examined was the presence on the site of the declaration of accessibility which according to the Web Accessibility Directive [12] and the Italian legislation must be published on the website [25]. The second considered aspect was the conformity status to the European guidelines, which must be declared in the accessibility declaration according to the EU executive decision 2018/1523 [14]. The last one investigated the feedback methods declared by the municipalities in the accessibility declaration: this issue, required as mandatory by current legislation [25], is a key aspect that allows anyone to notify the public sector body about any failures of the website.
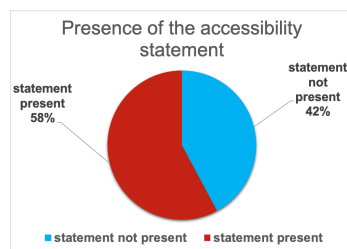

Fig. 3. Results of the analysis on the presence of the accessibility declaration in the sites of the 102 municipalities in the province of Padua.
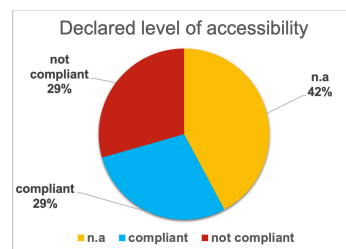

Fig. 4. Results of the analysis on the accessibility level declared on the accessibility declaration of the 102 municipalities in the province of Padua.
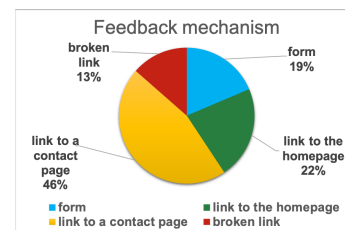
Fig. 5. Results of the analysis on the type of feedback mechanisms provided on the accessibility declaration of the 102 municipalities in the province of Padua.

Among the analyzed sites, 43 sites did not present any declaration as depicted in Figure 3. Considering only the remaining 59, 43 are fully compliant with the mandatory legislative requirements and 29 are only partially compliant, so only 29% of the analyzed websites are fully compliant with the Accessibility legislation (see Figure 4). Moreover, if we analyze the mechanisms offered to provide feedback about inaccessibility issues (shown in Figure 5), they are present only in 59 websites, 11 provide a form for the feedback, 13 a generic link to the homepage of the site, which never provides any feedback mechanism, 27 are links to a textual static contacts page and 8 are broken links or links that do not refer to any type of feedback mechanism.

A further perspective on the national situation can be found in the analysis of the 7,713 homepages owned by the Italian municipalities. The study [38], which based the analysis on the WCAG 2.0 standard, highlighted that "problems with accessibility are present in the vast majority of websites". The analysis, which used AChecker[2] and VaMolà[3] to test the website's accessibility, found that "government regulation is respected only by about 12% of Italian municipalities, a value that is reduced to less than 5% if we consider probable error", that are the errors that have been "identified as probable barriers, but require manual control of a being human to make a final decision".

3 RELATED WORKS

Due to its importance, the scientific community has focused its attention on accessibility [22], [24], but very little has been done to improve knowledge about accessibility guidelines among web developers.

Many authors developed tools to improve accessibility for a particular category of users with disabilities [4, 9, 19, 26, 31], e. g., a browser's extension for users with dyslexia [4], websites designed for children with Autism Spectrum Disorders [9] or the use of voice speakers to improve users interaction with the websites [19]. Accessibility issues related to screen readers have been discussed in [5], where the authors considered blind people as active users in terms of developing and employing browsing strategies to overcome accessibility issues. Furthermore, in [18] the authors reported the outcome of an interview with a blind person focusing on the issues he directly experienced while browsing the web through a screen reader. These works propose solutions for a particular situation and a restricted set of users, e. g. inaccessibility of CAPTCHA for visually impaired users [3, 23], but do not help the diffusion of knowledge about the accessibility problem as a whole.

Even if the World Wide Web Consortium (W3C) has defined the Web Content Accessibility Guidelines (WCAG) [40], there is still a lot to do in this direction. For instance, an empirical study involving 32 blind users showed that many problems faced by these users cannot be captured by the WCAG [33]. During the test, the users had to navigate 16 websites and, as a result, 1,383 accessibility issues were reported and only 50.4% of them are covered by the WCAG 2.0. The paper suggests moving from a problem-based approach toward a design principle approach. Calvo et al [7] reported that many websites are still not accessible since AA level of the WCAG 2.00 does not cover all the problems encountered by users with disabilities. The study was conducted by seven accessibility experts who had evaluated 62 mobile and desktop websites as well as mobile applications. The experts highlighted potential issues which were not covered by the guidelines but could deeply affect the navigation of people with disabilities. Therefore, not so many developers know and implement the WCAG but, making the situation even worse, the WCAG standard is inadequate to fully guarantee accessibility.

The authors of [21] analyzed websites over a period of 14 years. They showed that improvements in accessibility are mainly due to the advent and use of new and more intrinsically accessible technology rather than to an actual effort by the authors of the websites. As a result, Web accessibility is still a main issue and even top-traffic and government websites suffer from multiple violations of accessibility rules [17],-[31], [35].

Lengua et al [27] reported that accessibility guidelines are often perceived as hard to understand, not suitable for practical problem solving, and proposed the Sighted Architects Helper for Aria Notation (Saharian), a browser extension available for Google Chrome to increase integration between development tools and accessibility testing tools in usual web development workflows. In particular this extension helps authors to simulate the visualization of web browser with the eyes of people with visual impairment. Sloan et al [36] discussed the need for an all-encompassing methodology

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[2]https://achecker.achecks.ca/
[3]http://www.iosandemetrio.edu.it/vamola/checker/

for determining the level of accessibility of web resources and the requirement that the results of such a procedure are as meaningful as possible to developers. The authors stated that accessibility evaluation methods are unsatisfactory in the scope and presentation of their results.

Snider et al [37] studied the questions asked about accessibility, both through information searches and direct queries, within a large multinational corporation over a period of two years, finding an emphasis on topics covering enterprise requirements for testing, recording, and reporting compliance. They realized a question-answering accessibility conformance chatbot.

A screening application able to compute accessibility-related metrics was presented and discussed in [30]. This tool is specifically intended for enabling public institutions to face and (hopefully) solve accessibility issues; yet, it can provide metrics and synthesis of the time evolution of websites to any website manager. Instead, in [29] the authors proposed a tool to monitor Web accessibility from a geopolitical point of view, by referring resources to the institutions which are in charge of them and to the locations they are addressed to.

Similarly, in [8] Carvalho et al investigated the navigation of four websites performed through mobile devices. Their usability test included six blind users and four mainstream users and reported 514 problems and/or violations, 409 experienced by blind users and 105 by users without visual impairment. More in detail, the main issues involved the lack of navigational aids, unclear interaction, and absence of text alternatives for images.

4 MYWCAG4ALL

MyWcag4All has been created with the aim to help web developers to learn which are the issues that must be considered and techniques to use during the development of a website. In fact, what usually happens is that the developers often know that accessibility legislation exists, but they do not know what to do to be compliant with that law. MyWcag4All wants to fill this gap: it provides designers and developers a tool, in particular a website, where they can efficiently consult a list of web accessibility rules, tools for testing, and possible solution.

The website is divided into two sections, one public and one which needs authentication. The public section is composed of three pages:

- **"Homepage"**: the landing page of the tool, allows access to the private section with a login or to create a new login;
- **"Tools"**: in this section, the user can consult a list of testing tools and services dedicated to accessibility;
- **"Myths and Stereotypes"**: in this section, the user can examine a list of myths and stereotypes related to the world of digital accessibility and consult some sources that deny them. The aim of this page is to spread accessibility culture, discrediting wrong beliefs.

The core of the MyWcag4All platform can be accessed through login and then the user is allowed to insert, modify or delete a site, and view the website's list. Once the user inserted a website, they can associate a test suite to it: using the "Accessibility" section it is possible to view a list of test and WCAG criteria and select which ones apply to their website and which are not, thus defining a list of test to perform. For each test, the system explains the rationale, the associated criteria, and a list of tools that can be used. Moreover, the "Tools and resources" page gives a complete list of tools and services dedicated to accessibility. The user can also add a new tool to the list through the form if it is missing.

The web application also proves a "Profile" page, where the users can find information about themselves and the their websites, change the password, or delete their profile. The tool also provides a "Ranking" page, where users are listed on the basis of the sum of the points collected passing the test on each of their websites.

4.1 Test suite

MyWcag4All is an extension of WCAG4All. First of all, we expanded the test list with 14 additional tests to adapt it to the latest WCAG working draft [40]. Then, to improve the usability of the system, we reclassified the tests on the bases of 5 categories which are more easily understandable even by developers not experts in accessibility. The categories, and subcategories, are:

- Structure (html, form, tables, navigation aids, structural orientation, link, separation between contents and layout)
- Presentation (CSS, no CSS, images, colors, layouts, animations)
- Behavior (dynamic elements, keyboard, input modes, errors, usage time, authentication)
- Contents (text, images, graphs, data, media, cognitive overload, disorientation)
- W-Aria (states, roles, properties)

This classification of the tests requires less effort for the user to obtain information about a test since the number of categories was strongly reduced (from 23 to 5) and, if previously each test belonged exclusively to one of the 23 categories, now each test could appear in more than one of the 5 new categories, each of which has a number of sub-categories. The use of a non-exclusive categorization allows to better characterize the multifaceted nature of every single test and increases the probability that the user understands which is the right category for searching.

As an example, the former test number 47, which concerns "Three Flashes" WCAG 2.3.1 criteria, initially belonged only to the "multimedia" category. Now it appears both in the presentation "category", since it deals with multimedia objects that usually are used to create the layout, and in the "behavior" category since multimedia elements have their own behavior (play, stop, pause), subject to WCAG laws.

Similarly, we enriched the mapping between tests and WCAG criteria. In WCAG4All, each test was linked to only one WCAG criterion, now we have deeply studied the WCAG criteria and have associated each test with all the proper WCAG criteria. As an example, the former test number 6, which concerns duplicates id and was initially associated only with the 2.4.10 "Headings section" WCAG criteria, now is associated with two more criteria: 1.3.1 "Info and Relationship" and 1.3.6 "Identify Purpose".

4.2 Interactivity

One of our main goals was to add interactivity to our previous work [17], in such a way as to involve the user proactively. The most interactive part is the private section. As already discussed, the test list is interactive: each test can be marked as applicable to the site or not, and, when the user completes the test they can check the "completed" checkbox, which indicates that the test was fully passed on the site. The list also contains the essential information for each test: number, short title, associated WCAG level, type of test, and the two check boxes indicating its status (applicable or not, passed or not) as shown in Figure 6. In the detail of the test, it is also possible to observe its description and the procedure that must be implemented to pass the WCAG and AGID criteria with which it is associated.

Once the user has selected which tests are applicable to the website, he, or she, can move to the "WCAG 2.2" page. This page has the goal to record which criteria are satisfied and which are not, to calculate the level of accessibility of the site (i. e., A, AA or AAA). The page organizes the criteria according to the 4 WCAG principle, *Perceivable*, *Operable*, *Understandable* and *Robust*. The list of criteria is marked as passed or not based on the test-criteria mapping discussed in Section .

Fig. 6. Interactive accessibility test suite in the "Accessibility" page of MyWcag4All. At the time of writing the interface is available on in Italian.

Fig. 7. "Ranking" page of MyWcag4All

The user can control the list of criteria and how they are marked, and the steps to the results page where he, or she, can find the conformity statement of the site and other useful data, displayed using both text and dynamic charts, that describe, the tests that were passed or not for each WCAG level, which are applicable or not, and explain the score achieved by the website. This conformity statement is based on the AGID requirement and is:

- non compliant: if the web site passed less than 50% of the tests;
- partially compliant: if the web site passed more than 50% and less than 100% of the tests;
- fully compliant: if the web site passed 100% of the tests.

4.3 Gamification elements

To better involve the users, increasing their engagement in completing site-related tests [20], we added some gamification elements to the website, in particular, we assign points to each passed test and publish the best results on a leaderboard.

The number of assigned points is based only on the type of test: manual tests are scored with 3 points because they require more time and skills, semi-automatic tests are scored with 2 points and automatic tests with 1 point. This scale of scoring is rough and it is not representative of the real difficulties of creating sites that are compliant with the specific test: a more realistic scoring can be created by balancing this aspect, and also the level of importance of the test's aim, based on opinions by people who habitually use assistive technologies for surfing online.

The leaderboard can be viewed by all registered users. The hall of fame lists users by score totalized in every site they monitor within the MyWcag4All.

4.4 Spread of Accessibility Culture

The culture of accessibility is pursued in two sections. In the first, "Myths and Stereotypes", we deal with false myths and stereotypes regarding accessibility. Here, through a kanban board-like layout, the user can discover and deepen the most popular myths and stereotypes concerning accessibility. For each one, there is a small card that contains the explanation as to why the myth or stereotype is not true and some useful sources linked to the subject.

The second one, "Tools", present both in the public and in the private part, concerns the tools that a developer should use to deal with accessibility. A collection of 80 tools is available (see Figure 8), that cover the whole spectrum of the development process of a site, from the first moment to the last testing phase.
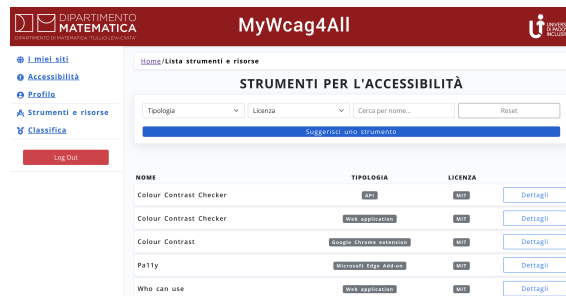
Fig. 8. "Tools and resources" section of MyWcag4All

4.5 Privacy and data concerns

Data provided by the users are only a username and an email, in line with the 5th article of the GDPR, which establishes the principle of minimization of the requested data [13]. Data collected about a website can also be easily anonymized by the user: the title is a user prerogative and the URL field is not mandatory.

4.6 The React library

The site was developed using the React library [28]. One of the issues relating to the development of an accessible site is often the use of libraries and their accessibility. In this case, it was definitively not an impossible challenge, but it required extra work and a bit of experience.

The critical aspects found while we developed this web application was the component-based nature of the React and the HTML generation done by some external modules.

The official recommended method to develop a React application is to split the UI into components following the single responsibility principle [34]. Therefore the final user interface is an aggregation of single or groups of components. Taking care of accessibility from the beginning is fundamental but not enough: if a single component, for example, a button, can meet all the accessibility requirements individually, this is not necessarily the case if it is composed inside another component, like a form. It is fundamental to take this aspect into consideration and test, step by step, all the single components, then the aggregations, and finally the entire website to avoid losing accessibility.

React is a Javascript library whose main purpose is to create user interfaces. Anything not provided by the React library must be written from scratch or provided by installing external modules, making React a library and not a framework. JSX is a widely used syntactic extension to Javascript especially when ES6 is used. The compiled JSX code that generates Javascript code, which finally renders HTML code, can sometimes be syntactically invalid or lack accessibility, especially when using external modules, whose care of accessibility is left to the creators.

Therefore, external libraries that provide graphic components or logic functions must not be used uncritically as if they were black boxes. Instead, their accessibility must be assured before use, even looking at their source code if necessary.

5 CASE STUDY

MyWcag4All was used in a contest open to Computer Science, Data Science and Cybersecurity students of University of Padua. The contest aims to award the most accessible and beautiful web site in order to fight one of the main stereotypes that bother web accessibility, because it erroneously links accessibility to aesthetically unpleasing user interfaces.

Ten groups of students participated to the contest, 9 used MyWcag4All during the development process of the websites and 8 answered to a survey about the tool. We asked these groups, that are made up of 3-4 student each for a total of 30 people to compile a questionnaire in which they could evaluate their collective experience with MyWcag4All. All of them declared to have used the tool in the final phases of the development process, i. e., verifying and testing accessibility. This is partially due to the timing of the availability of the tool, which was published after the group have begun to work on their project.

Assessing how helpful the tool was, in a 5-points Likert scale from 1 to 5, four groups gave a neutral score (3) , 3 groups a value of 4 (useful), and one group a value of 2 (a little useful), as depicted in Figure 9. Moreover, as shown in Figure 10, the participants judged the checklist for the accessibility tests as the most useful while the least useful feature was the pre-compilation of the WCAG criteria.
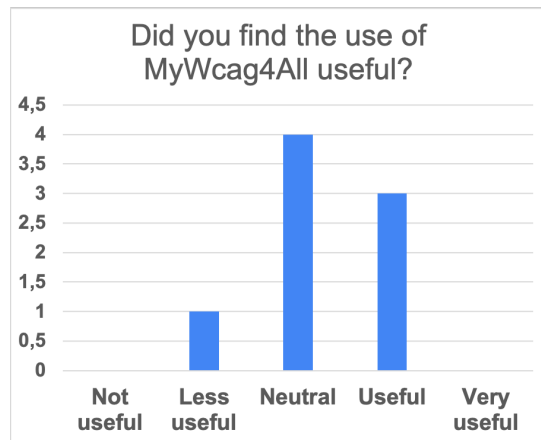

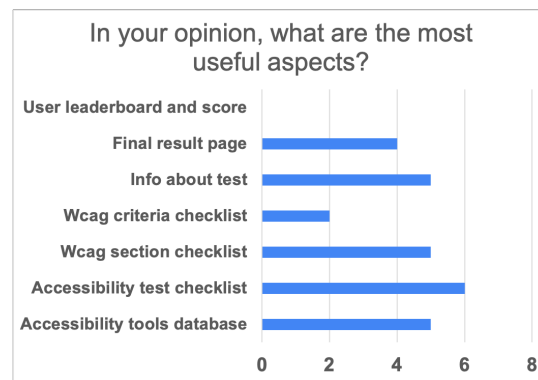Fig. 9. Answer to the question "Did you find the use of MyWcag4All useful?".

Fig. 10. Answer to the question "In your opinion, what are the most useful aspects?".
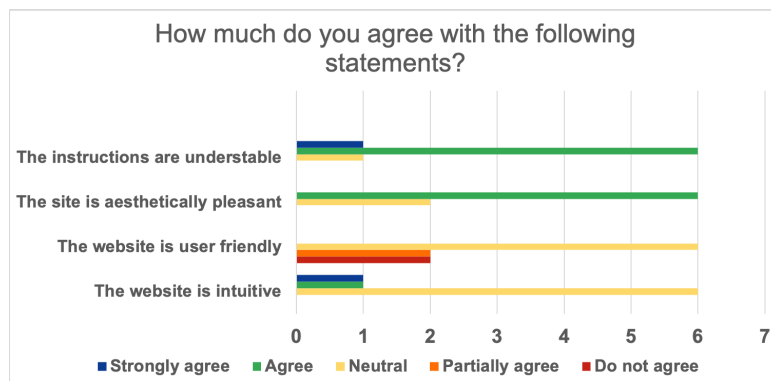

Fig. 11. Answer to the question "How much do you agree with the following statements?".

The survey also highlighted that the instruction are understandable and 6 groups liked the aesthetic of the website (the other 2 groups gave a neutral score, see Figure 11). Unfortunately, the participants thought that the website was not

very user-friendly nor intuitive. For this reason, after this first testing phase, we enhance MyWcag4All, following the feedback given by the participants in an open survey. In particular, we improve the user interface, the data persistence, and consistency, thus improving also global stability. This was achieved with the use of Redux, a React package.

6 CONCLUSION

Accessibility is still insufficiently dealt with and, unfortunately, poorly implemented. Our survey showed that there is a lack of culture about this subject because, despite innovative international technological standards and recent legal obligations, a wide range of sites struggle to meet the minimum accessibility requirements. Moreover, developers have some general knowledge about the topic but do not know what they must do to create websites that are compliant with the minimum level of accessibility. MyWcag4All tries to fill this gap by providing a complete suite of accessibility tests, useful in all development phases, and a dataset of relevant information on these tests and on many accessibility tools available online usable in a simple, dynamic and innovative way.

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