Accessibility Evaluation of Top-ranking University Websites in World, Oceania, and Arab Categories for Home, Admission, and Course Description Webpages

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Abstract

Evaluating accessibility is an important equity step in assessing the effectiveness and usefulness of online learning materials for students with disabilities such as visual or hearing impairments. Previous studies in this area have indicated that, over time, university websites have become gradually more inaccessible. This paper relates findings of a quantitative, comparative study of university website accessibility for students with disabilities. Sampling comprised a random selection of 20 universities from each of the Academic Ranking of World Universities top 100, Oceania region top 50, and Arab region top 50 ranked universities. AChecker evaluations of three types of website from each university—the home page, the admission page, and a course description page, revealed a total of 30,944 accessibility related home-page errors among the 180 evaluated webpages. Comparison with earlier studies reveals no significant improvement in the accessibility of university websites between 2005 and 2015. There were also no differences in accessibility levels amongst the selected top-ranking universities in the world. Therefore, there is a growing need for universities to improve accessibility of online learning materials for students with disabilities.

Keywords: accessibility; LMS, students with disabilities; evaluation tool; AChecker; university website

Introduction

As the use of e-learning systems increases, so distance learning and learning management systems (LMS) are used more and more to distribute information. At the same time, the number of university students with disabilities has increased dramatically. Although developers have facilitated accessibility and provided new tools and features for web applications, these systems still have limitations, and gaining access to online content and web-based resources is increasingly complicated for students with disabilities. The socially preferred view of university website accessibility is one of equity—an environment in which all students, including those with disabilities, have full access to the websites.

Educational websites facilitate academic success for users with disabilities if the websites are designed for accessibility. Online courses provide enhanced solutions for students who experience barriers to attending traditional courses because of sensory or physical disability (Paciello, 2000). As a group, visually impaired individuals are most affected by inaccessible educational systems (Paciello, 2000). A study by Fichten, Jorgensen, Havel, and Barile (2006) evaluated university website accessibility for students with disabilities, and indicated that almost half of the population of students with disabilities have more than one disability. This finding is

consistent with other literature, which shows that a significant number of students suffer from double impairments (Fichten et al., 2006). Most students with disabilities in this study indicated that they need adaptive assistive technologies to effectively interact with a university website. Examples of such adaptive innovations are writing software such as WYNN and TextHelp, and screen-reader software such as ReadPlease and Jaws. Many students who use adaptive technologies confirm using more than one type of technology; these individuals are usually concerned about compatibility requirements for these technologies (Fichten et al., 2009).

Fichten et al. (2009) explored website issues for Canadian universities as reported by 223 students with disabilities, 58 campus disability service providers, 28 professors, and 33 educational developers. Online questionnaires were administered to the participants. The results showed that the principal accessibility problems exhibited by university websites that used LMSs were a lack of accessible digital audio and video materials, inflexible time limits for online exams, lack of accessible PowerPoint slides, extensive use of inaccessible PDF-based course materials, and lack of essential adaptive technologies. The students highlighted technical difficulties such as problems downloading and opening files, webpages that do not load, and slow downloading of videos. The disability service providers identified the professors' lack of practice in using educational websites, and the lack of accessible course materials. The educational developers also discussed the inaccessibility of digital course materials. The professors commented on their own lack of knowledge about working with an LMS, and also identified the problems raised by the other groups.

Student achievement and LMS interaction are strongly related. Educational data mining of the time spent on online resources and digital contents shows the effect of log-on time on student achievement. (Jo, Yu, Lee, & Kim, 2015). Analytical studies of LMS databases have proven that students who interact regularly with LMS components achieve higher grades than those who do not (Baker & Inventado, 2014; Peña-Ayala, 2014). Moreover, Ringlaben, Bray, and Packard (2014) used accessibility evaluation tools AChecker and Bobby to evaluate 51 special education department websites in the United States. They found that most (97%) of the pages examined had accessibility problems, many of which (39%) should be regarded as high priority issues needing urgent resolution. Hackett and Parmanto (2005) highlighted the need to increase accessibility rates in higher education websites in tandem with the increasing complexity of web content. Zap and Montgomerie (2013) found that only 0.7% of 383 Canadian post-secondary websites achieved ratings of 'Free of Priority 1 Errors' and 'Free of Priority 2 Errors' based on the Bobby evaluation tool. Harper and DeWaters' (2008) evaluation results showed that one-third (33%) of all the university websites examined did not comply with any of the Bobby evaluation tool's priorities, and no home pages met the World Wide Web Consortium (W3C) guidelines.

The use of web-automated evaluation tools is popular because they facilitate the elimination of accessibility barriers (Vigo, Brown, & Conway, 2013). Most automated evaluation tools, such as AChecker, classify accessibility errors into "known", "likely", and "potential" errors. For example, providing descriptive text for non-text elements can be classified as a known error when it does not have the 'alt' attribute in the HTML code for embedded media in webpages. This situation can also be classified as a likely error if the 'alt' attribute exists but does not contain adequate descriptive text. Potential errors are detected when the accuracy of descriptive text is low (AChecker Adaptive Technology Resource Centre, 2015).

This study evaluates the current state of the accessibility of university websites from the top-ranking universities in the world, Oceania, and Arab regions.[1] The results of other studies from

[1] This group includes Harvard University, Cambridge University, and the University of Tokyo; the remaining members of this category are a random selection of university sites from those ranked 1–100 in the world. Universities in Oceania and Arab regions are a random selection of universities ranked in the top 50 for those respective regions.

different periods are compared to show statistically whether enough attention has been paid to accessibility issues by these university systems. A review of the literature from 2005 to 2014 shows the need to improve university website accessibility. Findings from those studies are compared with the findings from the present study to determine if this is still the case.

The remainder of this paper is presented in four sections. In the first section, the problem of accessibility in Australian higher education is discussed (Australia is part of the Oceania region). The second section describes the study design. The third section reports findings from the study and the fourth section presents a discussion and set of general conclusions that can be drawn from the study with suggestions for future research.

Participation of students with disabilities in Australian higher education

The 2012 Survey of Disability, Ageing and Carers (Australian Bureau of Statistics, 2012) showed that 1.5 million people with disabilities in Australia need formal assistance from an organised service provider for at least one activity of daily living. For a proportion of these people, this includes assistance with communication. The number of Australian students with disabilities has been increasing in recent years. In 2014, the percentage of these students in Australian universities was around 10% (Australian Government, Department of Education and Training, 2015). Students with disabilities in Australia continue to be disadvantaged in terms of access to, and participation in, higher education. In 2012, 41% of the population in the 15-to-65-year age group completed a bachelor degree or better in Australia. This was made up of 15% who had disabilities and 26% of non-disabled (see Fig. 1) (Australian Disability Clearing House on education and Training, 2016). Increasing access to university websites through policy formulation, practice, system design, and implementation that are specific to users with disabilities aims to advancing their achievement in higher education institutions.

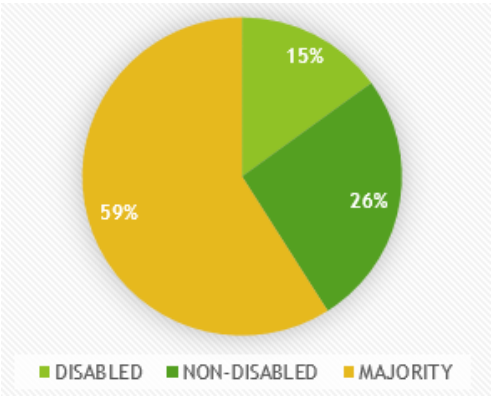

Fig. 1 Individuals aged 15 to 65 with higher education qualifications

In an investigation of the population of students with disabilities at one Australian university, we found a significant growth in the number of students with disabilities between 2011 and 2014. For example, Fig. 2 shows the number of students with visual or hearing impairments at one university from 2011 to 2014. The graph reveals a slight increase in the number of students who have hearing or visual impairments in 2014, and a decrease in the number of individuals with both visual and hearing impairments in the same period.

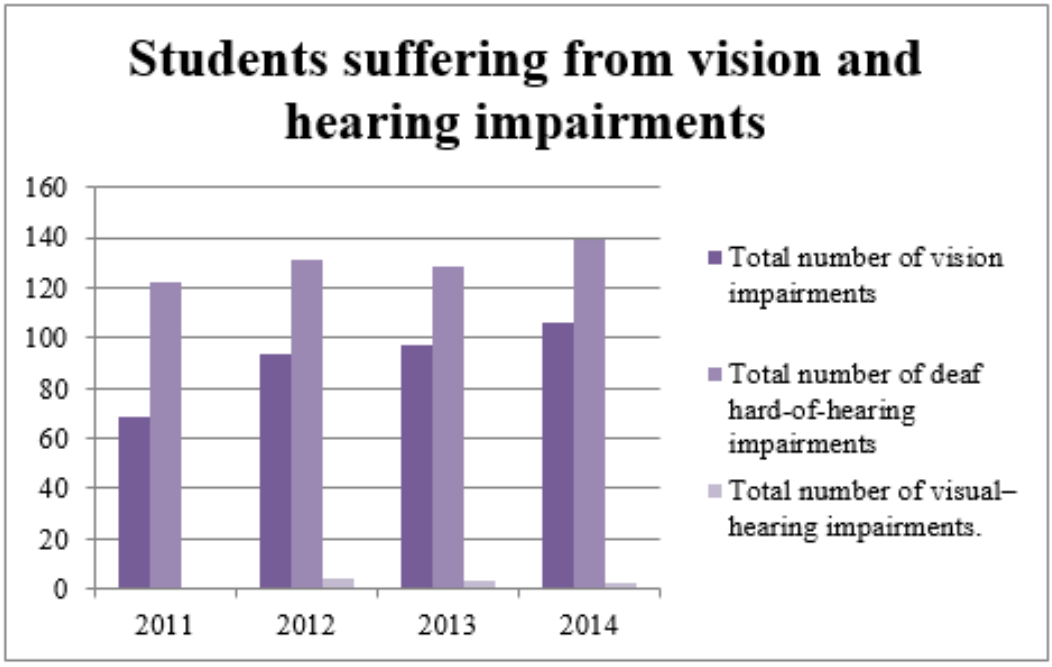

Fig. 2 Number of students suffering from visual, hearing, and visual–hearing impairments (2011–2014)

Also, in 2014, 31.63% of students with disabilities left university without completing their degree programmes. Only 18.42% of such students completed their degree programmes, and approximately half of all students with disabilities graduated with a grade point average (GPA) of less than 5 out of 7. Table 1 presents some of the achievement details of students with visual or hearing impairments. The table shows a considerable rise in the percentage of visually impaired students who successfully completed their degree programmes from 2011 to 2014. For example, 28% of students completed their degrees in 2012 whereas, in 2014, about 21% of such students acquired their degrees. From 2011 to 2013, the percentage of retreating students (i.e., those who withdrew from the university) rose considerably from 21% to 31%, but decreased to approximately 19% in 2014.

In addition, the percentage of hearing impaired students who successfully completed their degree gradually increased from 2011 to 2013, and then slowly declined to 2014. The percentage of retreating hearing impaired students gradually rose from 23% in 2011 to 30% in 2014. Overall, these percentages show that, in 2014, the proportions of achieving and retreating students were almost equal whereas, in 2013, the number of achieving students was higher than that of retreating students. Attention should be paid to more effectively supporting students with disabilities, including accessibility of educational websites.

Table 1 Performance of students with visual or hearing impairments (2011–2014)

Visually impaired students	**2011**	**2012**	**2013**	**2014**
Percentage of visually impaired students who successfully completed their degree programmes	14.49%	27.66%	18.56%	20.75%
Percentage of retreating visually impaired students	21.43%	25.00%	31.43%	18.57%
Hearing impaired students	**2011**	**2012**	**2013**	**2014**
Percentage of hearing impaired students who successfully completed their degree programmes	18.85%	22.14%	30.23%	29.50%
Percentage of retreating hearing impaired students	22.62%	23.60%	24.71%	29.63%

Assistive technologies such as Braille output systems, modified keyboards, screen enlargement utilities, voice output utilities, and other technologies allow students with disabilities to have better access to information on educational web-based systems. On the other hand, the content and resources of many systems has become more complex, especially with the emergence of Web 2.0 technologies such as blogs, multimedia, and wikis; therefore, much information cannot be accessed with assistive technologies, software, and hardware alone. There is growing evidence to suggest that universities have failed to keep up in addressing accessibility errors, whether they relate to assistive technology issues, multimedia content, or document files. This study highlights the number of accessibility errors commonly found in 60 university websites across three regions. Addressing them will benefit students with disabilities, and professors, by providing a general overview of the current accessibility errors. Finally, findings from the present study provide insights into the design of development guidelines, standards, and codes, and raise awareness of LMS or university sites' accessibility for students with disabilities.

In the next section we explain the study design and approach, and we include details of the site selection process and the evaluation method used to support the study's aim of rating the accessibility of systems used by the top universities.

Study design/approach

The selection process for participating universities was based on the Academic Ranking of World Universities (ARWU), which is conducted by researchers at the Center for World-Class Universities at Shanghai Jiao Tong University (ShanghaiRanking Consultancy, 2015). We chose top-ranking universities to demonstrate how accessibility is addressed inadequately even in universities that have good resources and budgets. The evaluations are based on the top university rankings in the world, Oceania, and the Arab regions in 2015; the sample comprised 20 university websites from each of the three categories.

The top universities in the world category were selected to demonstrate the struggle with accessibility issues despite their location in developed countries. This group includes Harvard University, Cambridge University, and the University of Tokyo; the remaining representatives in this category are derived from a random selection of university sites from those ranked 1–100 in the world. Universities in Oceania, selected randomly from the top 50 ranked universities, include the Australian National University, Monash University, and the University of Otago. In the Arab category, accessibility issues were considered in developing countries such as the Kingdom of Saudi Arabia, Egypt, and the United Arab Emirates, and the participant universities (including King Saud University, Cairo University, and United Arab Emirates University) were randomly chosen from the region's top 50 schools. The selection included examples from

developed and developing countries to show how accessibility issues affect all countries, regardless of whether they have accessibility regulations (Cooper, Sloan, Kelly, & Lewthwaite, 2012) or they need to work on establishing regulations that compel compliance with accessibility principles (Abanumy, Al-Badi, & Mayhew, 2005).

The data collection method was based on collecting HTML source code from the selected webpages, all of which are publicly available online. The focus of this study was to evaluate the accessibility of the pages that are considered to have the greatest effect on students: each university's home page, one course description page, and one admission page (Jo, Yu, Lee, & Kim, 2015). (Because the home page is the first page that a student is likely to encounter on a university's website, it creates the first impression, and the university is likely to lavish much more care and attention to detail on its construction. The rest of the website is structured as a 'tree' of linked web pages that may be one or more navigation steps deeper into the website. It is likely, therefore, that less attention will be paid to accessibility and other quality features on those pages.) From these three webpage types, 180 webpages were chosen randomly for evaluation from the 20 university websites. In addition, an evaluation revealed the change in the number of accessibility errors encountered when navigating from the home webpage to a course outline webpage. Finally, the evaluations included a comparison of accessibility errors found on sites originating from evaluated websites.

The analysis method used here is based on two analytical tools: AChecker and SPSS.

AChecker

AChecker (AChecker Adaptive Technology Resource Centre, 2015) is a software tool that can be used to analyse individual webpages for accessibility. It produces a report of all accessibility errors for selected guidelines and identifies three types of errors: known, likely, and potential errors. "Known errors" have been identified with certainty as accessibility barriers. "Likely errors" have been identified as probable barriers but require a human to make a final decision. "Potential errors" are those for which AChecker cannot identify an effect, so a human decision is required. An example of the AChecker evaluation process is presented in Fig. 3.

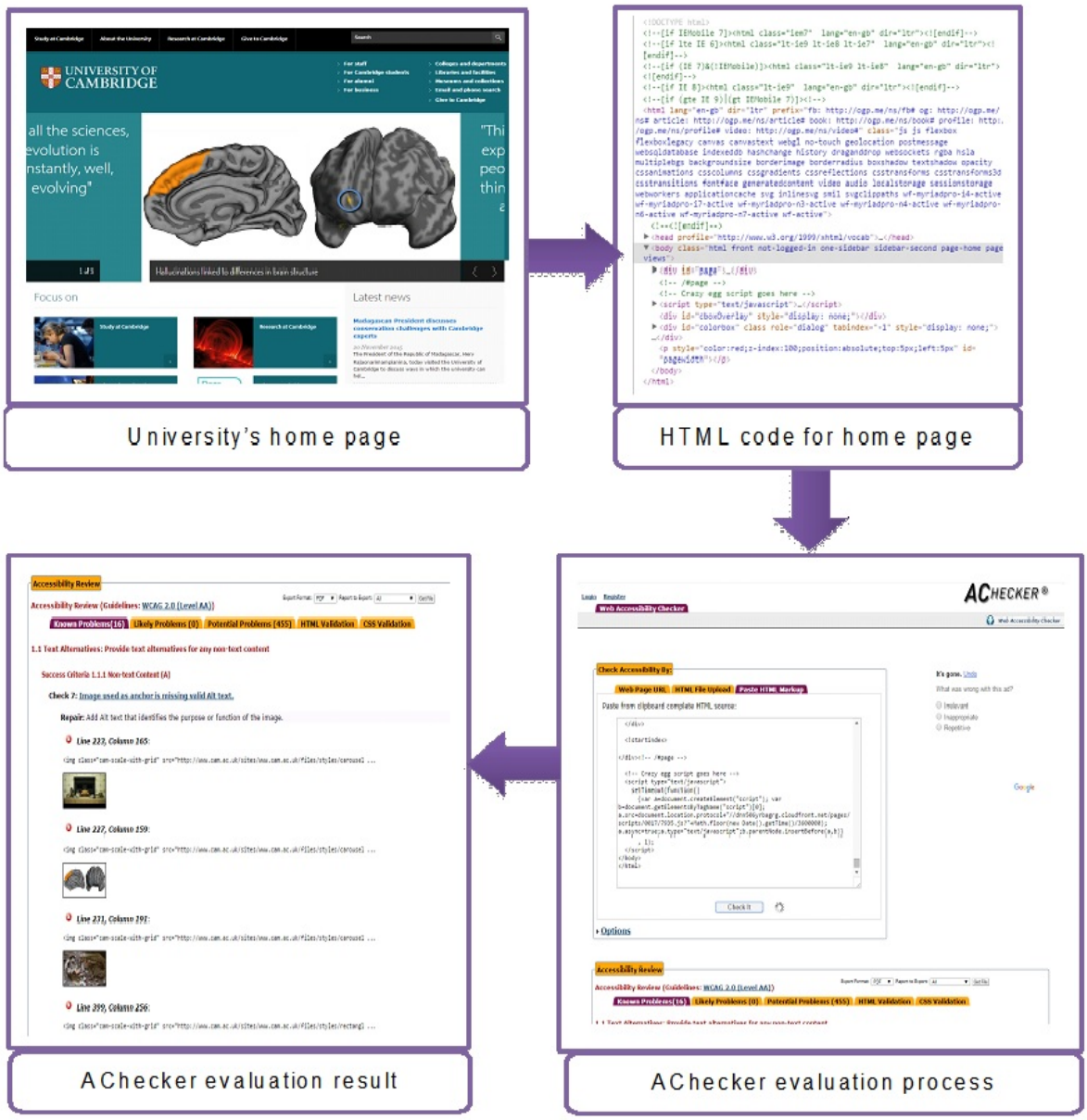

Fig. 3 An example of the AChecker evaluation process

We configured AChecker to identify and count the errors that violate the Level AA standards of the Web Content Accessibility Guidelines 2.0 (WCAG 2.0) in each webpage. WCAG 2.0 is the set of guidelines most commonly used by most educational organisations and LMSs, including Blackboard, Moodle, and Skillsoft. It is a balanced, referenceable, and technical framework with 12 standards that are categorised into four concepts, namely: perceivability, operability, understandability, and robustness. Each standard has three levels of testable success criteria. The lowest is Level A, in which one of the criteria is the provision of alternative text that provides equivalent objectives to all non-text elements that are displayed to end users. The second (modest) level is Level AA, wherein one of the requirements is the presentation of captions for audio and video elements in synchronised content. The third (highest) level is Level AAA, which includes a criterion for the provision of sign language interpretations for all recorded audio and video elements in synchronised content. Level AAA standards also require the satisfaction of all success criteria for a webpage to pass the accessibility requirements of disabled individuals (World Wide Web Consortium, 2008). WCAG 2.0 has been updated to include guidelines for evaluating Web 2.0 components such as wikis and multimedia content.

SPSS

A second analytical tool employed by the present study is SPSS, which is used to analyse and report the numerical data gathered from AChecker reports for each selected university system. The SPSS reports are organised by webpage type and region.

Key questions

The study used comparative quantitative analysis to answer the following questions:

- What is the current accessibility rate for university websites?
- How does accessibility rate differ with webpage type?
- How do accessibility rates differ between university webpages in the different regions?
- What are the most common errors in webpages that affect accessibility?
- How do the findings of this study compare with other studies conducted during different periods?

The evaluation and resulting analyses that answer these questions will be discussed in the findings.

Findings

The AChecker output showed a significant number of accessibility errors in the three webpages evaluated for each selected university website among the 60 top world, Oceania, and Arab universities. Figure 4 presents an overview of the accessibility issue throughout the world, showing the mean total number of errors in each country of the chosen regions in this study. For example, the mean of known, likely, and potential errors in the home, admission, and course description pages for all chosen universities sites from Australia is around 1000. The mean number of total errors reflects the global issue of accessibility concerns, showing it is a problem in all participant universities.

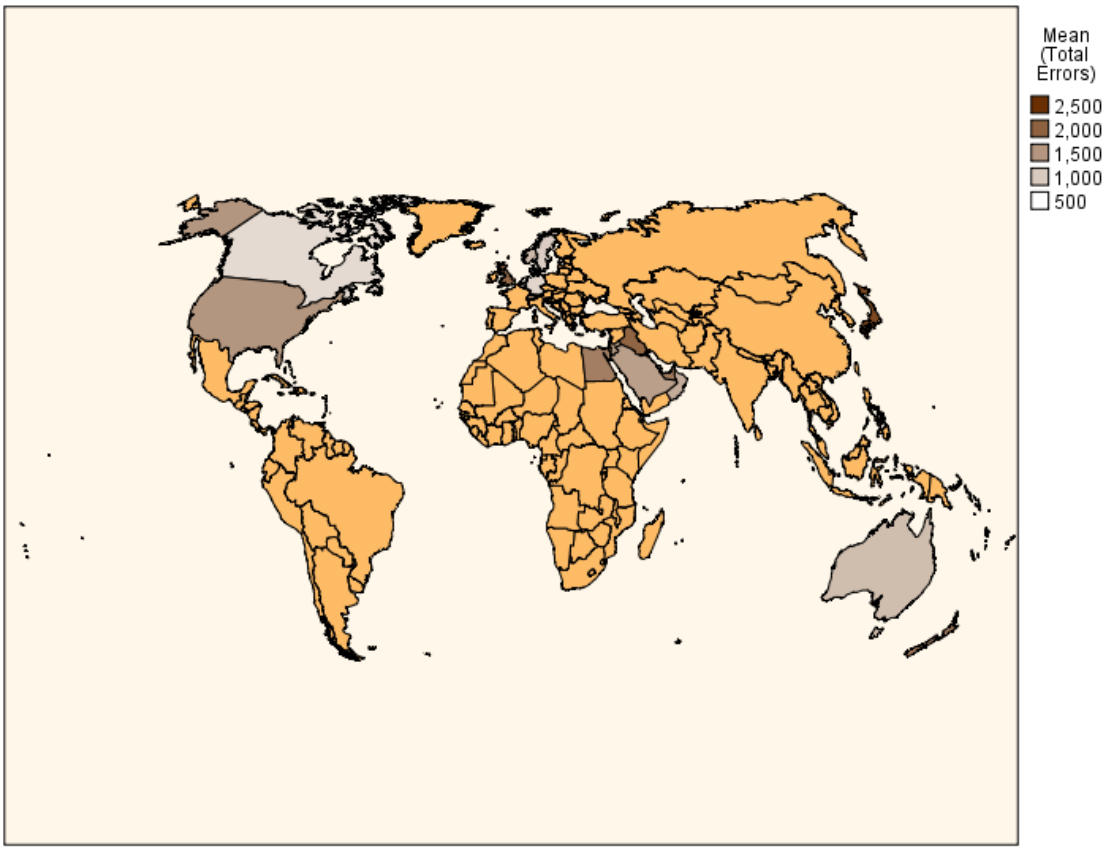

Fig. 4 Mean total number of accessibility errors in university websites from the world, Arab, and Oceania regions

This section is organised into four subsections:

1. Accessibility rate by webpage type
2. Accessibility rates of university webpages in the three categories.
3. Comparison of studies conducted from 2005 to 2015.
4. Common errors that affect accessibility.

Accessibility rate by webpage type

Table 2 shows the total number of known, likely, and potential errors in the home, admissions, and course description pages for all of the selected university sites. Of the 82,685 errors on the 180 pages, there were 30,944 home page errors (37.42% of the total), 24,433 admission page errors (29.55% of the total) and 27,308 course description page errors (33.03% of the total). The AChecker evaluation tool searched for issues that did not meet WCAG 2.0 standards, at Level AA. The expected number of errors increased by 30% when AChecker was set to Level AAA. In sum, the accessibility issue is considered a worldwide phenomenon.

Table 2 Descriptive statistics summary for total home, admission, and course description webpage errors for all selected universities

		Home page errors	Admission page errors	Course description page errors
N	Valid	60	60	60
	Missing	0	0	0
Mean		515.73	407.22	455.13
Minimum		23	51	45
Maximum		1149	1623	3293
Sum		30944	24433	27308

A t-test was conducted to compare accessibility errors for webpage type in home and course description pages ($p = .415$), home and admission pages ($p = .732$), and admission and course description pages ($p = .331$). The Levene's test for equality of variances is non-significant in all webpage types. These results indicate that there is no relationship between the webpage type and the number of errors.

Accessibility rates of university webpages in the three categories

The total number of all error types—known, likely, and potential—for each region is aggregated and shown in Fig. 5. A comparison of the total number of all error types shows that the number of accessibility errors is high regardless of their origin in the developed world (e.g., the United States, the United Kingdom, Australia, and Japan) or in developing countries (e.g., Egypt, Saudi Arabia, and Lebanon). These numbers demonstrate uniformly that minimal attention is paid by universities to accessibility of their online content in the three regions.

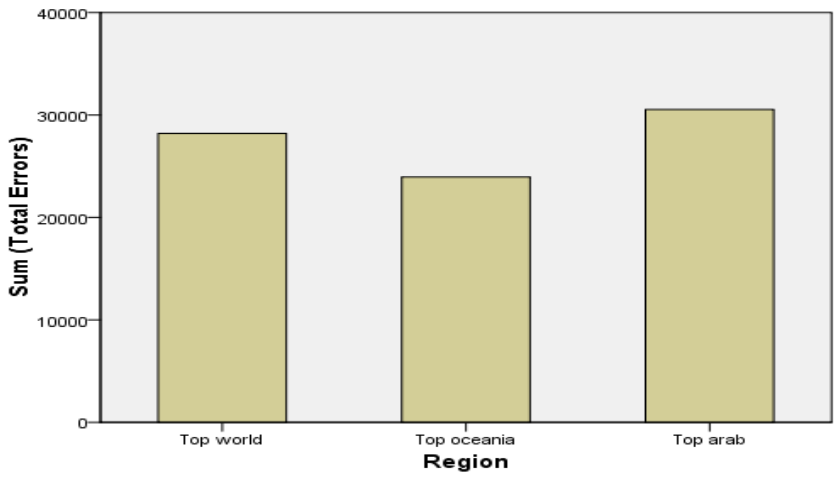

Fig. 5 Total number of home, admission, and course description page errors in university webpages from each region (2015)

A t-test was conducted to compare accessibility errors for webpages in the world and Arab regions ($p = .529$), world and Oceania regions ($p = .332$), and the Arab and Oceania regions ($p = .054$). The Levene's test for equality of variances is non-significant in all regions. These results indicate that accessibility issues affect university websites in all regions, and there is no significant difference between them. Accordingly, there are no differences in accessibility rates among top-ranking universities.

An example of accessibility rates in the world region

Tables 3, 4, and 5 illustrate findings from among the world's top universities. Table 3 shows the descriptive statistics relating to the known, likely, and potential errors on the home pages. The maximum number of known errors is 414, the number of likely errors is 15, and the number of potential errors is 629. This number of errors on the home pages suggests a lack of any plan to design enhanced accessibility for students with disabilities that could affect their achievement. If users find a high number of errors on a home page, it is likely that they will see an increase in the number of errors as they navigate to other pages in the university's website.

Table 3 Known, likely, and potential errors on the home pages of the world's top universities (2015)

		Known errors	Likely errors	Potential errors
N	Valid	20	20	20
	Missing	0	0	0
Mean		30.25	1.80	386.75
Minimum		0	0	210
Maximum		414	15	629
Sum		605	36	7735

Table 4 shows the descriptive statistics for the known, likely, and potential errors on the admission pages of the universities in the world category. The maximum number of known errors on the 20 pages is 943, the number of likely errors is 10, and the number of potential errors is 1025.

Table 4 Known, likely, and potential errors on the admission pages of the world's top universities (2015)

		Known errors	Likely errors	Potential errors
N	Valid	20	20	20
	Missing	0	0	0
Mean		58.45	2.10	351.65
Minimum		0	0	111
Maximum		943	10	1025
Sum		1169	42	7033

Table 5 shows the descriptive statistics relating to the known, likely, and potential errors on course description pages of the world's top universities. The maximum number of known errors among 20 pages is 841, the number of likely errors is 6, and the number of potential errors is 3073.

Table 5 Known, likely, and potential errors on course description pages of the world's top universities (2015)

		Known errors	Likely errors	Potential errors
N	Valid	20	20	20
	Missing	0	0	0
Mean		63.40	1.35	514.20
Minimum		0	0	60
Maximum		841	6	3073
Sum		1268	27	10284

Comparison of studies conducted from 2005 to 2015

The comparison of the total number of known errors on the three types of pages shows there are significantly more on the admission and course description pages than on the home pages. (i.e., there were 1268 known errors on the course description pages compared with 605 known errors on the home pages). The number of potential errors is higher than known errors for all evaluated pages, while the likely errors occur least frequently. Most potential errors relate to the accessibility of multimedia content, such as lacking synchronised captions for video or audio, lacking (or inaccurate) descriptive text for images or video, and a lack of cues for reading and navigation order. Correcting these errors requires human action, and relies on a well-designed accessibility development plan to check pages, find solutions, and resolve the errors.

Common errors that affect accessibility

Table 6 presents examples of the top 10 errors under each error type as detected in 82% of the evaluated pages. The table includes the WCAG 2.0 success criteria and the level that was unmet, thus leading to each error. In all, the accessibility issue is present in all universities in the three categories. There is no relationship between the page type and number of errors.

Table 6 Examples of known, likely, and potential errors

Known errors	WCAG (success criteria, level)	Likely errors	WCAG (success criteria, level)	Potential errors	WCAG (success criteria, level)
Image element missing alt attribute	Success Criteria 1.1.1 Non-text Content (A)	P element may be misused (could be a header)	Success Criteria 1.3.1 Info and Relationships (A)	Alt text is not empty and image may be decorative	Success Criteria 1.1.1 Non-text Content (A)
Input element, type of "text", missing an associated label	Success Criteria 1.3.1 Info and Relationships (A)	Suspicious link text	Success Criteria 2.4.4 Link Purpose (In Context) (A)	Tabular information may be missing table mark-up	Success Criteria 1.3.1 Info and Relationships (A)
Input element, type of "text", has no text in label	Success Criteria 1.3.1 Info and Relationships (A)	Image Alt text may be too long	Success Criteria 1.1.1 Non-text Content (A)	Visual lists may not be properly marked	Success Criteria 1.3.1 Info and Relationships (A)
Label text is empty	Success Criteria 3.3.2 Labels or Instructions (A)	Area opens new window may be missing warning	Success Criteria 3.2.2 On Input (A)	Unicode right-to-left marks or left-to-right marks may be required	Success Criteria 1.3.1 Info and Relationships (A)
Header nesting: header following h1 is incorrect	Success Criteria 2.4.6 Headings and Labels (AA)	Suspicious link text (contains placeholder text)	Success Criteria 2.4.4 Link Purpose (In Context) (A)	Dir attribute may be required to identify changes in text direction	Success Criteria 1.3.1 Info and Relationships (A)
B (bold) element used.	Success Criteria 1.4.4 Resize text (AA)	Select element may cause extreme change in context	Success Criteria 3.2.2 On Input (A)	Input element label, type of "text", is not positioned close to control	Success Criteria 1.3.1 Info and Relationships (A)
Document language not identified	Success Criteria 3.1.1 Language of Page (A)	Title text may be too long	Success Criteria 2.4.2 Page Titled (A)	Text may refer to items by shape, size, or relative position alone	Success Criteria 1.3.3 Sensory Characteristics (A)
Document has invalid language code	Success Criteria 3.1.1 Language of Page (A)	ASCII art possibly missing a skip-over link	Success Criteria 2.4.1 Bypass Blocks (A)	Image may contain text with poor contrast	Success Criteria 1.4.1 Use of Color (A)
ID attribute is not unique	Success Criteria 4.1.1 Parsing (A)	Select element may cause extreme change in context	Success Criteria 3.2.2 On Input (A)	Input possibly using colour alone	Success Criteria 1.4.1 Use of Colour (A)
Missing text equivalent to embed element	Success Criteria 1.1.1 Non-text Content (A)	List item used to format text	Success Criteria 3.2.4 Consistent Identification (AA)	Script user interface may not be accessible	Success Criteria 2.1.1 Keyboard (A)

The AChecker reports generated from the 180 pages were manually evaluated to identify the accessibility errors common to 60 university websites. These common errors are listed below (ranked from higher to lower frequency):

1. Missing alternative text
2. Linked image missing alternative text
3. Alternative text is null or empty
4. Webpage language is missing

5. Empty link
6. Missing first-, second-, and third-level headings
7. Unordered lists
8. Missing synchronised captions for video
9. Missing audio or video descriptions
10. Lack of cues for reading and navigation sequence
11. Not all webpage functionality is available using the keyboard
12. No time control if a webpage or application has a time limit
13. Lack of descriptive or informative webpage title
14. Inaccessible document files (e.g., PDFs, Word, and Excel files).

From the above analyses and descriptive statistics, it is clear that accessibility issues affect university websites in all regions, and that there is no significant difference among them. Also, there are no differences in accessibility rates among top-ranking universities (see Table 2 and Fig. 5). There is no relationship between the number of accessibility errors and webpage types. The university website errors that most commonly affect accessibility relate to the accessibility of media content or files (e.g., missing alternative text); assistive software issues (e.g., missing first-, second-, and third-level headings); document file issues (e.g., inaccessible uploaded document files); and the lack of navigation information (e.g., lack of cues for reading and navigation).

Comparison of this study with those conducted 2005–2015

The comparison of this study's 2015 evaluation with the evaluations presented in the literature published between 2005 and 2015 showed that accessibility issues continue to require attention from universities, educational organisations, developers, and professors. Only a slight improvement has been achieved, and the complexity of the issue and its consequences remain high. Table 7 summarises the findings of this research in comparison with those of other studies conducted at different times. Comparisons with these earlier studies indicate that although university websites have become gradually more inaccessible with the growing complexity of their content, universities continue to neglect this issue.

Table 7 Findings from this study compared with other studies conducted 2005–2015

Study by	Year	Case	Country/Region	Tool	Findings
Hackett & Parmanto	2005	Educational and government websites	USA	Bobby	(85%) of educational websites considered to be inaccessible
Harper & DeWaters	2008	Educational websites	Not specified	Bobby	(33%) of all websites were not compliant with any of the Bobby priorities
Zap & Montgomerie	2013	Post-secondary websites	Canada	Bobby	(0.7%) of 383 websites received 'Free of Priority 1 Errors' and 'Free of Priority 2 Errors'
Ringlaben, Bray, & Packard	2014	Special education department websites	USA	AChecker and Bobby	(97%) of the pages examined had accessibility errors
Alahmadi & Drew (proposed study)	2015	University website	Top ranking universities in World, Oceania, and Arab regions	AChecker	(37.42%) of the accessibility errors are accrued in home pages

The discussion and conclusion summarises this study's findings and an analysis of the data gathered from the number of accessibility errors. The conclusion also offers suggestions for future work.

Discussion and conclusion

Today, educational websites and LMSs are essential for institutions of higher education, and their accessibility to students with disabilities is paramount to their learning. As the empirical findings revealed, serious errors are made in terms of the accessibility of media content or files such as images, audio files, and video content. Substantial accessibility related difficulties are also encountered in document files such as PDFs, Word files, and Excel data, all of which are used extensively in university webpages. Moreover, there are errors relating to the availability and accuracy of descriptive texts for the non-text components of websites and how such information is structured. Identifying the most frequent errors provides a foundation for classifying them into core categories and carrying out further evaluation. These errors demonstrate the importance of considering disability characteristics when designing and implementing accessibility principles in university websites, and the results of this study highlight the urgent need to develop a set of guidelines based on the features and learning materials on university websites. Such guidelines might increase accessibility awareness among professors and developers.

This study found no significant difference in accessibility in relation to the number of accessibility errors and the type of webpages. For example, analysis of each of the websites maintained by the 20 selected universities in the world category demonstrated a lack of accessibility in homepages (37.42% of total errors), admission pages (29.55% of total errors),

and course description pages (33.03% of total errors). This finding indicates that webpage type does not affect the accessibility rate, and that incorporating type as a parameter in accessibility evaluation methods (such as metrics for educational websites) might not go far enough to ensure accessibility. Nor was any significant difference found in the accessibility ratings of university systems among top-ranking universities in the world category. The number of errors in the websites of universities in each region highlights a lack of local and international regulatory effects on the issue of web accessibility. Regulation of university websites to ensure compliance with accessibility principles may be a necessary step towards improving accessibility.

There has been no notable improvement in the accessibility of university websites between 2005 and 2015 (Table 7). This finding indicates that the accessibility of university websites and LMSs is a complex issue, to which several research endeavours and approaches have been devoted to increase accessibility and usability. The comparison of our results and those of previous research show that a multi-method approach is needed to overcome the shortcomings of the solutions that are currently available.

In recent years, system interaction has had a considerable effect on students with disabilities—although they regularly interact with university websites and LMSs, accessing online information and completing online tasks are often challenging (Jo, Yu, Lee, & Kim, 2015). Supporting the accessibility of online learning materials for students with disabilities is expected to reduce attrition rates. If this population sees that an organisation supports their learning, enrolment and retention could increase. To achieve these goals, universities should strive for higher levels of accessibility and usability in their websites; in return, students will experience substantial changes in their university lives

Quantitatively understanding the current state of accessibility of university websites may lead to the development of a framework that can be used to assess the effectiveness and usefulness of online learning materials for students with disabilities (Alahmadi & Drew, 2016). Another worthwhile endeavour is to implement a model that supports the creation of adaptive accessible content with minimal effort from professors and general content authors.

In the future, a meaningful initiative for researchers and developers will be to focus on solutions for specific accessibility issues based on students' experience when they interact with LMSs and online pages, rather than on assessments of pass or fail accessibility guidelines or evaluations. Other beneficial strategies are to avoid one-size-fits-all user interfaces and to employ adaptability and adaptive content that is tailored to the abilities and characteristics of students with disabilities.

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