Enhancing accessibility in STEM: A survey of accessibility errors in STEM academic databases

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Academic libraries must provide accessible electronic and information technology to patrons using assistive technology to access library materials. Accessibility of scholarly material is particularly important in the STEM disciplines, where attrition rates of students with disabilities is higher than in other fields. In this study, the accessibility of STEM indexing databases was evaluated using the WAVE accessibility tool, and the frequency of errors, alerts, and features encountered during completion of typical searching tasks for each database was noted. The use of accessibility checking tools like WAVE can supplement other methods used to verify the accessibility of vendor-created library databases.

Keywords: accessibility; academic libraries; abstracting and indexing databases

Introduction

Librarians have come to recognize that "unequal access to digital technologies brings about unequal participation in society" (Van Dijk, 2005, p. 15). In the context of higher education, librarians must ensure that users of all abilities have access to the digital tools and information needed for their education, teaching, and research. This responsibility of academic libraries has been clearly stated in policies of library professional organizations (American Library Association, 2001).

While equal access to digital library materials and tools is important for students and faculty in all areas of study, evidence suggests the students with disabilities in STEM disciplines face unique barriers in the successful completion of their higher education. The display of technical content such as equations, charts, and figures by assistive technology, and the frequent incompatibility of indexing databases with assistive technology are some of the challenges in accessing literature in the STEM fields faced by users with disabilities. In this study, the accessibility of databases used to index and abstract the scholarly literature in STEM fields was evaluated using the WAVE accessibility checking tool, and the frequency of WAVE items (errors, alerts, and features) encountered during completion of typical searching tasks for each database was noted. Accessibility checking tools like WAVE can be used to complement other methods (e.g., third-party evaluation or vendor documentation review) in determining the level of conformance of a commercial library database with accessibility standards.

Literature review

Challenges for STEM students with disabilities

Librarians have an ethical duty to provide patrons with disabilities access to information, and access must be equal and equitable. Libraries can play a catalytic role in the lives of people with disabilities by facilitating their full participation in society. Libraries should ensure that the library policies, resources, and services meet the needs of all people (American Library Association, 2001). Access to digital library resources goes beyond support of educational outcomes, and researchers interrogating the digital divide have found that, "unequal access to digital technologies brings about unequal participation in society," (Van Dijk, 2005, p. 15). Disability tends to overlap with other disadvantaged positions in society, often multiplying impacts of exclusion (Dobransky & Hargittai, 2016). Some research suggests that equal access to the internet is the most pressing civil rights issue facing people with disabilities (Jaeger, 2012), and 2020 census data shows that the digital divide impacts civil rights and social equity on multiple levels (Berry-James et al., 2020). As emergency measures during the COVID-19 pandemic required online learning, it became clear that digital accessibility must be prioritized (Erlam et al, 2021). Higher education institutions are making strides towards inclusive digital accessibility, however, they are still hindered by different conceptualizations of terminology, unclear responsibilities for staff, and varying levels of support from senior leadership (Lomellini, 2022). It is therefore essential that academic librarians continue to ensure that users, no matter individual ability, have the opportunity to access the digital tools and information necessary for their education.

Students with disabilities (SWD) and accessibility needs are often excluded from discussion of equity in STEM teaching and learning (Duerstock & Shingledecker, 2014; Lee, 2022; Schneiderwind, 2021; Strand, 2019). Over the past two decades university enrollment by people with disabilities has increased, while the amount of corresponding research has decreased (Schneiderwind & Johnson, 2020). SWD enroll in STEM fields at the same percentage in which they are represented in the population (Booksh & Madsen, 2018; Friedensen, Lauterbach, et al., 2021; Thurston et al., 2017). However, the attrition rate for SWD is higher in STEM disciplines (Friedensen, Lauterbach, et al., 2021; Lee, 2014; Riggs, 2022), and faculty with disabilities are under-represented in higher education when compared to peers without disabilities (Friedensen, Horii, et al., 2021). Since 2001, students with disabilities have more than doubled from 5% to 11% of the undergraduate population, but they comprise only 5% of the graduate student population. This disparity indicates that graduate education is not accessible for students with disabilities (Wells & Kommers, 2022). Furthermore, the scientific community benefits from the inclusion of diverse individuals, and addressing barriers to accessibility is a necessary step towards encouraging a truly intersectional academic community within the STEM disciplines (Devitz, 2023). Librarians have a role to play in addressing the higher attrition rate of SWD in STEM disciplines by ensuring that SWD have accessible and comprehensive access to academic resources.

Multiple factors including class size, pedagogical style, unavailable learning aids, and lack of accommodations from faculty influence the higher attrition rate for SWD in STEM disciplines (Booksh & Madsen, 2018; Gilligan, 2020; Thurston et al., 2017). The impact of disability status intersects with other student identities to impact STEM course completion (Bellman et al., 2015; Lister et al., 2022). Furthermore, there are accessibility challenges specific to STEM resources, and librarian competency is referenced as a barrier for SWD in STEM disciplines (Vuletich et al., 2022). While Vulelitch focuses on the challenges created for SWD by the unique content of STEM manuscripts (content such as equations, charts/graphs, and figures), this study evaluates the accessibility of STEM databases. These resources play a central role in the discovery of STEM scholarly literature, and they are therefore critical tools that must be accessible for all STEM faculty and students.

Accessibility evaluation of library databases

A variety of methods for evaluating the accessibility of library databases have been described in the last twenty years of literature in the fields of librarianship, education, and computer science; a selective sample of such descriptions follows.

Librarians as test subjects. Several evaluations of online databases by librarians without disabilities acting in the role of surrogate users have appeared in the library literature. In a study by Riley (2002), three aggregator databases were evaluated by sighted librarians for their adherence to accessibility guidelines; using a variety of assistive tools the librarians evaluated each database on multiple screens, and full-text records were retrieved and evaluated using several screen readers. Stewart and Narendra (2005) evaluated over 120 databases from 37 vendors for compliance with the accessibility standards of Section 508 and WCAG, using minimally trained subjects to perform search-related tasks using adaptive software. After developing a ten-component checklist from accessibility standards and personal experience, Tatomir and Durrance (2010) evaluated 32 databases using adaptive technology and flagged key accessibility features missing from the databases.

Evaluation by authentic users of assistive technology. A number of studies have featured the accessibility evaluation of library databases by visually impaired users of assistive technology. Horwath (2002) collected ratings, comments, and issues from 11 blind or visually impaired computer users who were asked to perform a series of search and retrieval tasks using four proprietary library databases. Byerley and Chambers (2002) evaluated the adherence of two multidisciplinary databases to accessibility standards by asking blind users to perform a series of common tasks, with a librarian recording verbal comments on the issues they encountered. Dermody and Maidkodunmi (2011) recruited university students with print disabilities to perform typical discovery and retrieval tasks in three subscription databases, making audio/visual recordings of the tasks and conducting post-task surveys to characterize the barriers encountered. In a study by Haanperä and Nieminen (2013), a non-sighted individual skilled in the use of assistive software performed four search/retrieval tasks using four digital academic library databases, evaluating both accessibility and usability. Michalak and Rysavy (2020) asked a non-sighted library student worker using assistive technology to navigate the library's website, access several multidisciplinary library databases, and provide comments on the challenges they encountered.

*Vendor self-reporting; vendor surveys and document inspections***.** Several studies which rely on database vendors to *evaluate* or *document* the accessibility of their products appear in the library literature. Byerley and Chambers (2003) conducted email surveys to elicit statements from 11 database vendors on the compliance of their products to Section 508 standards; four years later a follow-up study was conducted via web-based survey of 12 database vendors using questions about product accessibility similar to those posed in the original survey (Byerley et al., 2007). A study by Fernandez (2018) captured accessibility efforts being made by vendors by inspection of vendor documentation including 1) publicly available accessibility statements by the vendor, 2) availability of a VPAT for the database, and 3) language on accessibility included in the text of the vendor's license with the library.

Third-party testing. Collaborative efforts by academic institutions to evaluate and document the accessibility of common library databases using third-party evaluation is a recent trend; libraries of the Big Ten Academic Alliance have cooperated in such an arrangement (Pionke & Schroeder, 2020; Schroeder, 2018).

Audit tools. Blechner (2015) used several browser extensions to evaluate the accessibility and usability of two legal research databases using criteria developed as part of web accessibility training at the University of Washington. Riley-Huff (2015) used the WAVE browser extension to evaluate the use of 5 specific accessibility design features (including HTML5 and ARIA) in a group of 99 library databases. Rysavy and Michalak (2020) also used the WAVE extension to tabulate the number of errors and alerts generated using a group of library resources including reference titles, content management systems, and subscription databases.

Given the multiple barriers that SWD and faculty with disabilities may face in higher education, library faculty may need to take a comprehensive approach beyond accessibility audits of resources to meet the needs of users with disabilities (Gin et al., 2021; Lister et al., 2022). Yoon and colleagues advocate for the use of mixed methods in accessibility evaluation, and for supplementing the use of audit tools with manual evaluations by users of diverse abilities (Yoon, Dols, et al., 2016; Yoon, Hulscher, et al., 2016). While specific needs of SWD cannot adequately be addressed in accessibility audits of STEM library resources alone, accessibility audits can serve as a launching point for librarians interested in improving the accessibility of STEM resources.

Materials and methods

Twenty-five indexing/abstracting databases across the STEM disciplines were identified for the accessibility evaluation (Table 1); this comprises all the STEM-related databases available to our institutional affiliates and listed on the library's website. Although most of the databases are available only by subscription, three of the databases are freely available to the public (Table 2).

[Tables 1 and 2 near here]

For each database, pages were identified corresponding to three database operations: 1) viewing the initial "welcome" or landing page, 2) viewing a list of documents retrieved by a keyword search, and 3) viewing the detailed record for an individual document. These three operations were chosen as being representative of tasks that database users would typically perform as part of routine searching, and which could be performed uniformly across all the databases being evaluated. The choice of these three operations is also regarded as the appropriate trade-off between efficiency and thoroughness in the evaluation. For the evaluation of the search results lists, display options or search refinements were used to create a uniform number of search results (20) on the page for all databases.

WAVE is a set of online tools that can be used to make web pages more accessible to users with disabilities by checking adherence to accessibility standards (WebAIM, 2023). Features of WAVE that supported its selection for this evaluation are:

- familiarity – used by one of the authors for a prior evaluation.

- scope – performs a check of multiple aspects of accessibility on one page at a time.
- standards – checks adherence to WCAG 2 standards.
- stability – developed and maintained by an established organization (WebAIM) associated with a research institute (Institute for Disability Research, Policy, and Practice) at a major university (Utah State University).

For the database evaluation, a browser version of WAVE was selected due to its suitability for checking pages that are password-protected (as most of the subscription databases in this evaluation are). Each page was analysed using the WAVE extension for Chrome browser, and the number and type of errors flagged by WAVE were recorded. Alerts, features, structures, and ARIAs (Accessible Rich Internet Applications, a technique to make dynamic content more accessible) noted by the checking tool were also recorded.

The number of WAVE items (errors, alerts, features, structures, and ARIAs) was compiled for each database and page type, then summed across all databases for a given page type, and further summed across all page types, which allowed an examination and ranking of the number of WAVE items both within and across page types. Similarly, the percentage of pages on which a particular WAVE item occurred was recorded and summed across databases and page types, providing an indication of the likelihood of encountering a particular WAVE item across databases and page types.

Since compliance to WCAG accessibility standards can be related to the occurrence of WAVE errors and alerts (WebAIM, 2023), these flagged items were the initial focus of our evaluation. Tables 3-4 present the counts and page percentages for the top WAVE errors, and Tables 5-6 present these metrics for the top WAVE alerts. We also tabulated the occurrences of WAVE features (items that enhance accessibility) in the STEM databases to provide a more balanced picture of accessibility of these resources; Tables 7-8 summarize these results.

Results

Frequency of WAVE errors

Errors represent the highest-severity items flagged by the WAVE tool; most WAVE errors can be directly related to violations of WCAG standards (WebAIM, 2023). Table 3 presents the WAVE errors that occur most frequently on each page type (landing page, search results page, item detail pages, or all page types) across the STEM databases. The WAVE error “very low contrast” occurs 1,152 times across all page types and is the most frequent error by a wide margin; the high count of this error results from the frequency of its appearance on landing pages and search results pages. The “empty link” error is the second-most frequent error across all page types (250 errors), followed by three errors related to form labels (“empty form label”: 227 errors; “missing form label”: 152 errors; and “multiple form labels”: 135 errors). Rounding out the list of most frequent errors is “broken ARIA reference” which occurred 85 times across all page types.

[Table 3 near here]

Table 4 presents the WAVE errors that occur on each page type across the STEM databases ranked by the percentage of pages with a particular error. Consistent with the ranking of errors by item count, the WAVE error “very low contrast” occurs on the highest percentage of all page types (65%), and this error occurs on about two-thirds of STEM database pages studied. The ‘empty link” and “missing form label” errors are ranked second and third and appear on 45% and 43% of all page types respectively.

Errors ranked fourth through sixth by percentage of all page types are: "broken ARIA reference" (34% of pages), "empty button" (27% of pages), and "missing alternative text" (26% of pages).

[Table 4 near here]

Frequency of WAVE alerts

Alerts represent lower-severity items flagged by the WAVE tool; alerts indicate barriers to accessibility that may not result in non-conformance to WCAG standards. Table 5 presents the WAVE alerts that occur most frequently on each page type across the STEM databases. The WAVE alert "redundant title text" occurs most frequently (1,235 alerts across all page types) and is the most frequent alert by a wide margin; the high count of this alert results from the frequency of its appearance on search results pages and item detail pages. The 'redundant link" alert is the second-most frequent alert across all page types (741 alerts), followed by "broken same-page link" (472 alerts), "underlined text" (386 alerts), "very small text" (331 alerts), and "device dependent event handler" (278 alerts).

[Table 5 near here}

Table 6 presents the WAVE alerts that occur on each page type across the STEM databases ranked by the percentage of pages with a particular alert. The WAVE alert "redundant link" occurs on the highest percentage of all page types (80%), and this alert occurs on over two-thirds of STEM database pages studied. The "redundant title text" alert ranks second using this metric and occurs on 58% of all page types. These two results lead to the conclusion that any page type of the STEM databases studied is likely to exhibit both of these alerts. Also appearing in the list of top WAVE alerts using this metric are “skipped heading level” (ranked third, occurring on 53% of all page types), “noscript element” (ranked fourth, on 46% of all page types), “very small text” (ranked fifth, on 34% of all page types) and “missing fieldset (ranked sixth, on 32% of all page types).

[Table 6 near here]

Frequency of WAVE features

WAVE features are page elements that can increase the ability of assistive technologies to navigate a webpage. Table 7 presents the WAVE features that occur most frequently on each page type across the STEM databases. The WAVE feature “form label” occurs most frequently (5,211 features across all page types) and is the most frequent feature by a wide margin; the high count of this feature results from the frequency of its appearance on search results pages and landing pages. The “linked image with alternative text” feature is the second-most frequent alert across all page types (1,477 features), followed by “language” (913 features), “alternative text” (257 features), “null or empty alternative text” (229 features), and “fieldset” (95 features).

[Table 7 near here]

Table 8 presents the WAVE features that occur on each page type across the STEM databases ranked by the percentage of pages with a particular feature. The WAVE feature “language” occurs on the highest percentage of all page types (97%), and this feature occurs on more than 90% of the STEM database pages analysed regardless of page type. The “form label” feature is ranked second using this metric and occurs on 92% of all page types. Also appearing in the list of top WAVE features using this metric are “linked image with alternative text” (ranked third, occurring on 89% of all page types), “alternative text” (ranked fourth, occurring on 55% of all page types), “skip link” (ranked fifth, appearing on 39% of all page types) and “skip link target” (ranked sixth, occurring on 36% of all page types).

[Table 8 near here]

Discussion

WCAG accessibility framework

Describing the WCAG accessibility framework provides context necessary to examine the top items (errors, alerts, and features) flagged by the WAVE browser extension for the STEM databases evaluated.

WCAG 2.x comprises 13 guidelines grouped according to four principles, each principle reflecting a positive outcome (perceivable, operable, understandable, and robust) for users (Web Accessibility Initiative, 2023a). Conformance to WCAG is based on success criteria associated with each of the 13 guidelines. To provide flexibility for situations requiring differing levels of accessibility, the standard defines three levels of conformance (ranging from “A” the least stringent, to “AAA” the most stringent) with each level corresponding to a unique set of success criteria under the thirteen guidelines (Web Accessibility Initiative, 2023b).

Conformance to a particular WCAG success criterion may be achieved using one or more of the “sufficient techniques” detailed by the standard. The use of a sufficient technique is not proscriptive, and developers are free to use other methods to meet WCAG success criteria including newer technologies such as HTML5 and WAI-ARIA (Web Accessibility Initiative, 2023c).

Table 9 shows the relationship of the top items flagged by the WAVE browser (summarized in Tables 3-8), WCAG success criteria, and typical “sufficient techniques” for achieving conformance. In some cases, a single item flagged by WAVE can indicate non-conformance with more than one WCAG success criteria.

[Table 9 near here]

Top WAVE errors

WAVE error: Very low contrast.

Adequate contrast between text and background colors is necessary to create perceivable text for all users, but particularly for those with low vision. To meet WCAG success criteria 1.4.3 for adequate contrast at conformance level AA, the sufficient techniques G18 and G145 recommend a contrast ratio of at least 4.5:1 for normal text and at least 3:1 for large text; for conformance with success criteria 1.4.6 at the more stringent AAA level, the sufficient techniques G17 and G18 suggest that contrast ratios should be increased to at least 7:1 for normal text and 4.5:1 for large text. Contrast checking apps, such as the one provided by WebAIM at https://webaim.org/resources/contrastchecker/, are available to determine the contrast ratio of a given combination of text size/color and background color.

The WAVE error "very low contrast" indicates contrast ratios below those suggested for conformance with both level AA and level AAA contrast standards; this WAVE error occurred frequently (1,152 occurrences on all page types, Table 3) and on a high percentage of pages (65% of all pages, Table 4) across the STEM databases examined. The lowest contrast ratio noted in the study was 1:23:1 for normal text.

WAVE error: Empty link.

Link text (and alternative text of images used as links) should be present and available to screen readers to provide users with an understanding of the purpose and action of the link. WCAG success criteria 2.4.4 (conformance level A) requires that the purpose of each link can be determined by assistive technology using the link text and surrounding text. The sufficient techniques G53, H30, and H24 recommend that links of all types (including those used for anchor elements and areas of image maps) be provided with text that adequately describes the link purpose or target; sufficient technique G53 recommends link text adequate to describe the link function in conjunction with surrounding text. A related but more stringent success criteria (2.4.9, conformance level AAA) requires that link purpose can be determined by link text alone without the surrounding text, and the same sufficient techniques mentioned above (G91, H30, and H24) are suggested for conformance with the more stringent criteria.

The WAVE error "empty link" indicates links with missing link text, which would certainly trigger non-conformance with WCAG success criteria 2.4.9 (conformance level AAA), and possibly result in non-conformance with success criteria 2.4.4 (conformance level A). While this error can occur because a link is missing associated link text, it can also be caused by the use of font icons or scalable vector graphics (SVGs) as links without including an ARIA-label. This WAVE error occurred frequently (250 occurrences on all page types, Table 3), and on a high percentage of pages (45% of all pages, Table 4) across the STEM databases examined.

Top WAVE alerts

WAVE alert: Redundant title text.

Title attributes are intended to advise the user of the purpose or function of an element such as a link, abbreviation, or image. The title attribute often appears as a tooltip when the user hovers over an element. Redundant title text is caused by attribute text that is similar or identical to the text of the element. For example the following link would be considered to have redundant title text:

Databases

In this example, the value of the title attribute is identical to the text of the link. In order to be accessible the title attribute should provide a distinct description of the link:

Databases

This WAVE alert, while not rising to the level of severity of an error, may confuse users of assistive technology and result in non-conformance with WCAG 4.1.2 (Level A). The sufficient technique H88 recommends using coding features in the manner intended by the HTML specification, which in this case means using a title attribute that is descriptive of the element without being redundant with the text of the element. This WAVE alert occurred frequently (1,235 occurrences on all page types, Table 5) and on a high percentage of pages (58% of all pages, Table 6) across the STEM databases examined.

WAVE alert: Redundant link.

This WAVE alert results from adjacent links leading to the same URL. This practice can cause confusion and added navigation for users of assistive technology. This warning is most often caused by an image and adjacent text both linking to the same destination. For example the following HTML for an image and link are redundant:

```
<a href="home.html>
    <img src="house.png" alt="a small house icon" />
```

```
</a>
<a href=”home.html>Home</a>
```

To reduce the navigational demands on screen reader users and aid in conformance with WCAG 2.4.4 (Level A), the sufficient techniques G91, H30, and G53 recommend that redundant links should be combined into a single link where possible, and redundant text or alternative text eliminated. This WAVE alert occurred frequently (741 occurrences on all page types, Table 5) and on a high percentage of pages (80% of all pages, Table 6) across the STEM databases examined.

Top WAVE features

Features, as identified by the WAVE accessibility checker, are elements on a webpage that likely improve accessibility. The WAVE tool will identify these elements during a website check. However, follow-up evaluation should be conducted to confirm the impact of these elements.

WAVE feature: Form label.

Descriptive labels are associated with form control elements on the page (examples of form control elements include text boxes, radio buttons, check boxes, and buttons). These labels are presented to users of assistive technology when the form control is accessed (e.g. when tabbing into a text box), helping to make these elements more perceivable (per success criteria 1.3.1, Level A) and navigable (per success criteria 2.4.6, Level AA). Their use is recommended by sufficient techniques H44, H65, and G131.

This accessibility feature occurred frequently (5,211 occurrences on all page types, Table 7) and on a high percentage of pages (92% of all pages, Table 8) across the STEM databases examined. While the frequent occurrence of this feature is encouraging, WAVE errors denoting issues with empty, missing, or multiple form labels also occur frequently in the STEM databases examined as shown in Tables 3-4. While not representing a “top error” in this study, it appears that further attention to form labels in the design of STEM databases is needed. This deficiency in form labels is consistent with the results of Riley-Huff (2015), who found form label errors in 59 of the 96 academic library databases evaluated.

WAVE feature: Linked image with alternative text.

When an image is included within a link, a clear indication of the purpose or action of the link should be conveyed to users through the alternative text for the image or through the link text as an aid. The alternative text for the image may be empty if the link text provides adequate description of the purpose of the link. These measures help to make the page more perceivable (per WCAG 1.1.1, Level A) and operable (per WCAG 2.4.4, Level A) for users, and these measures are recommended by the sufficient techniques G82, H30, and G53. This WAVE feature occurred frequently (1,477 occurrences on all page types, Table 5) and on a high percentage of pages (89% of all pages, Table 6) across the STEM databases examined.

Conclusion

Academic librarians must ensure that users of all abilities have access to the digital tools and information needed for their education, teaching, and research. It is evident that students with disabilities in STEM disciplines face unique challenges in the successful completion of their higher education. STEM databases play a central role in discovering STEM scholarly literature and represent critical tools that must be accessible to all STEM faculty and students.

The accessibility of databases used to index and abstract the scholarly literature in STEM fields was evaluated using the WAVE accessibility tool, and the frequency of errors, alerts, and features encountered during the completion of typical searching tasks for each database was noted.

Errors: Low contrast was the top accessibility error on a majority of pages of the STEM databases evaluated, occurring equally on all the page types examined (landing, search result, and item detail pages). This error would be expected to result in non-conformance with relevant WCAG success criteria at both the AA and AAA levels, but the error is relatively easy to avoid through appropriate choice of text size/color and background color, and by the use of contrast checking applications during website development.

Empty links and missing/empty/multiple form label errors also occur frequently in the STEM databases evaluated, and could also result in non-conformance of the pages with WCAG success criteria. The frequent occurrence of missing/empty/multiple form label errors is consistent with prior accessibility evaluations of academic library databases.

Alerts: WAVE alerts, while not necessarily causing non-conformance with WCAG success criteria, occur frequently in the STEM databases examined and create barriers to users of assistive technology. Redundant title text and redundant links were the top alerts identified in the evaluation; these items can generally be avoided by attention to HTML standards.

Features: The frequent occurrence of the WAVE features “form labels” and “linked images with alternative text” indicates attention on the part of developers towards the accessibility of STEM databases.

Overall: While specific needs of SWD cannot adequately be addressed in accessibility audits of STEM library resources alone, accessibility audits can serve as a launching point for librarians interested in improving the accessibility of STEM resources and can serve to focus the efforts of mixed methods studies and manual evaluations of STEM resources by users of diverse abilities.

Declaration of interest statement

The authors report there are no competing interests to declare.

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Table 1. Disciplinary distribution of STEM databases selected for evaluation

Database discipline	**Database count**
Biological Sciences	4
Chemistry	4
Engineering and Computer Science	6
Environmental Sciences	2
Health Science	4
Mathematics	2
Physics	3
Total	**25**

Table 2. Distribution of access to STEM databases selected for evaluation

Database access	**Database count**
free/public	3
subscription	22
Total	**25**

Table 3. Top WAVE errors (by error count) in STEM disciplinary databases

	WAVE errors (count)			
WAVE error description	**landing pages (N=25)**	**search results pages (N=25)**	**item detail pages (N=24)**	**all page types (N=74)**
Very low contrast	455	574	123	1,152
Empty link	21	115	114	250
Empty form label	6	169	52	227
Missing form label	26	113	13	152
Multiple form labels	4	104	27	135
Broken ARIA reference	13	33	39	85

Table 4. Top WAVE errors (by % of pages) in STEM disciplinary databases

	WAVE errors (% of pages)			
WAVE error description	**landing page (N=25)**	**search results page (N=25)**	**item detail page (N=24)**	**all page types (N=74)**
Very low contrast	64%	68%	63%	65%
Empty link	36%	36%	63%	45%
Missing form label	44%	60%	25%	43%
Broken ARIA reference	28%	32%	42%	34%
Empty button	24%	32%	25%	27%
Missing alternative text	16%	24%	38%	26%

Table 5. Top WAVE alerts (by alert count) in STEM disciplinary databases

	WAVE alerts (count)			
WAVE alert description	**landing page (N=25)**	**search results page (N=25)**	**item detail page (N=24)**	**all page types (N=74)**
Redundant title text	154	566	515	1,235
Redundant link	168	245	328	741
Broken same-page link	1	377	94	472
Underlined text	18	22	346	386
Very small text	11	122	198	331
Device dependent event handler	8	204	66	278

Table 6. Top WAVE alerts (by % of pages) in STEM disciplinary databases

	WAVE alerts (% of pages)			
WAVE alert description	**landing page (N=25)**	**search results page (N=25)**	**item detail page (N=24)**	**all page types (N=74)**
Redundant link	68%	76%	96%	80%
Redundant title text	56%	56%	63%	58%
Skipped heading level	48%	56%	54%	53%
Noscript element	48%	40%	50%	46%
Very small text	16%	40%	46%	34%
Missing fieldset	16%	56%	25%	32%

Table 7. Top WAVE features (by feature count) in STEM disciplinary databases

	WAVE features (count)			
WAVE feature description	**landing page (N=25)**	**search results page (N=25)**	**item detail page (N=24)**	**all page types (N=74)**
Form label	1852	2875	484	5,211
Linked image with alternative text	512	262	703	1,477
Language	283	324	306	913
Alternative text	48	86	123	257
Null or empty alternative text	95	103	31	229
Fieldset	27	56	12	95

Table 8. Top WAVE features (by % of pages) in STEM disciplinary databases

	WAVE features (% of pages)			
WAVE feature description	**landing page (N=25)**	**search results page (N=25)**	**item detail page (N=24)**	**all page types (N=74)**
Language	92%	100%	100%	97%
Form label	88%	100%	88%	92%
Linked image with alternative text	88%	80%	100%	89%
Alternative text	52%	44%	71%	55%
Skip link	36%	48%	33%	39%
Skip link target	32%	44%	33%	36%

Table 9. Selected top WAVE items in STEM disciplinary databases, with associated WCAG success criteria and sufficient techniques

WAVE item	**Item type**	**WCAG success criteria**	**WCAG conformance level**	**Typical WCAG sufficient techniques**
Very low contrast	error	1.4.3 Contrast (Minimum) 1.4.6 Contrast (Enhanced)	Level AA Level AAA	G18, G145 G17, G18
Empty link	error	2.4.4 Link Purpose (In Context) 2.4.9 Link Purpose (Link Only)	Level A Level AAA	G53, H30, H24 G91, H30, H24
Redundant title text	alert	4.1.2 Name, Role, Value	Level A	H88
Redundant link	alert	2.4.4 Link Purpose (In Context)	Level A	G91, H30, G53
Form label	feature	1.3.1 Info and Relationships 2.4.6 Headings and Labels	Level A Level AA	H44, H65 G131
Linked image with alt text	feature	1.1.1 Non-text Content 2.4.4 Link Purpose (In Context)	Level A Level A	G82, H30 H30, G53