

A critical reflection on refactoring the Web Witchcraft and Wizardry project

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Abstract

Abstract goes here.

1 Introduction

Web Witchcraft and Wizardry (Mulligan, 2024) is a website for children to learn the basics of web development through fantasy-themed metaphors. The original version of the website was neither accessible (except by accident) nor responsive. This essay reflects on the design and implementation of a refactored version of the project, focusing on accessibility, architecture, and quality of the new code. Detailed decisions are documented as comments in the source code, which should be read alongside this essay, so the essay focuses on higher level design decisions and reflections.

For reference the old and new landing pages can be seen in figures 1 and 2.

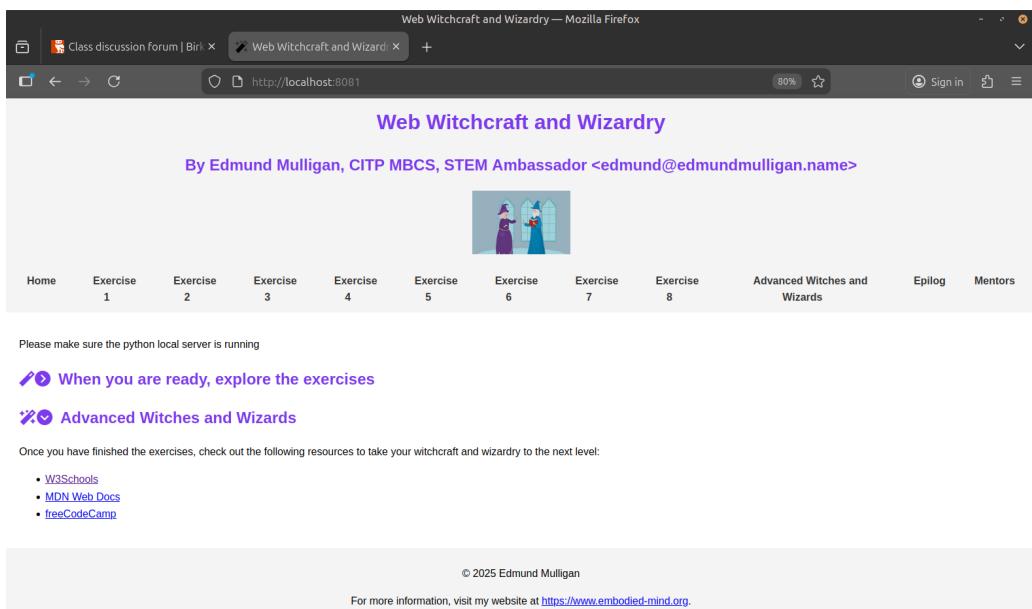


Figure 1: Old landing page

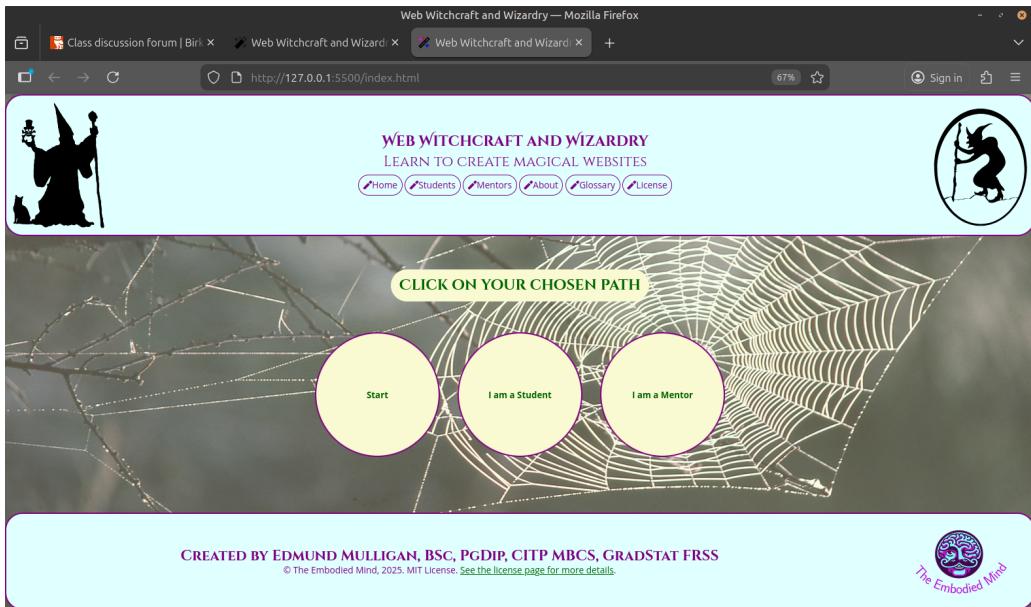


Figure 2: New landing page

The development process used was iterative and incremental (Beck and Andres, 2004), and while there are many criticisms of this approach, particularly around its lack of documentation, endless changes and lack of scalability to large teams (see, for example, Boehm and Turner (2004)), it was well suited to this small project with a single developer fulfilling all team roles.

2 Fundamental Design Choices

3 Responsiveness and Accessibility

A primary goal of the refactor was to make the website responsive and accessible.

4 Site Architecture and Navigation

information architecture and layout choices navigation design site navigation vs page navigation

5 Testing

Testing software is not only a critical part of development (Myers et al. (2011), Mesbah et al. (2012)), but it is also difficult and time consuming. Many authorities (e.g. Boehm (1981), Jones (2008)) claim that testing can take at least 50% of total development time, and that concurs with my experience.

My approach to testing was to automate as much as possible using open source tools (see Appendix B for results). The tests were designed to check for compliance with web standards and (given the age of the target users) text readability. Both static and dynamic testing tools (Myers et al., 2011) were used – static tools to check code validity, and dynamic tools to check accessibility and performance of the rendered pages.

The tests were run frequently during development to catch issues early and ensure that the code remained compliant as code was refactored (regression testing). A github action was written to ensure the tests were run whenever code was pushed to the remote development and

main branches in github. Testing tools were discovered using a google search and the most popular ones were chosen:

- Lighthouse (Google, 2024)
- Axe (Deque Systems, 2024)
- Pa11y (Pa11y Team, 2024)
- Wave (WebAIM, 2024)

A script to check reading age using the Flesch-Kincaid formula (Flesch, 1948) was also developed. Code was checked for validity using node.js modules html-validate (html-validate, 2024), stylelint (Stylelint Team, 2024) and eslint (ESLint Team, 2024). The official W3C validator for CSS (W3C, 2025) was not used as this cannot currently validate code with CSS variables. A simple script was written to ensure all files contained valid header comments. Browser compatibility was tested using Playwright Microsoft (2024) to run tests in multiple browsers and I acknowledge, with thanks, the assistance I received to get this working from a senior tester colleague at TfL. This allowed automated testing of all three major browser engines (Chrome, Firefox and Safari), although only the latest version of each was tested. Playwright has potential for much more and could enable a test driven development (TDD, Beck (2003)) approach in future phases of this project.

Implementing Wave testing was the most difficult as it requires a public URL to test and github pages are based on a private repository. Making the github repository public was considered and rejected as it could introduce unanticipated security risks so, after consultation with testing colleagues, ngrok (ngrok, 2024) was used to expose the localhost to allow Wave tests to complete.

There was insufficient time to fully evaluate the third party tools used and decide which was the best for this project, so a ‘black box’ approach was taken without investigating exactly what each tool was testing. This did have the benefit that gaps in one tool’s coverage could potentially be caught by one of the other tools, but it did introduce a problem of tools having conflicting standards. Wave, in particular requires the `<h1>` element to be in the `<main>` section, which would mean that the site title in the `<header>` section would have to be either an `<h2>` or a `<p>` element, which would be flagged by the other testing tools. Thus a decision to accept the warning from Wave was taken as the least bad alternative. The other alert from Wave was for the use of `<noscript>`, but this was simply a warning to check this usage as it may have accessibility implications.

Automated testing is not a substitute for manual testing, and the site was also tested manually on a variety of devices, specifically

- A computer with a mouse and keyboard (running Linux Mint)
- A computer without using a mouse (to test keyboard navigation)
- A computer with a screen reader (Linux Orca)
- A touchscreen tablet device without mouse or keyboard (running Android)
- A mobile phone (running Android)

I did not have access to an iOS device so could not test on Apple hardware.

The website was NOT tested with JavaScript disabled and this is acknowledged as a limitation of the current testing, driven by the available time. User testing was also not possible within the time constraints, but will be essential in the later phases where actual lessons are implemented. In particular, expert testing from an experienced teacher will be needed to ensure the content is age appropriate and pedagogically sound.

6 Third party credits and resources

All code submitted for assessment is my own work. No code has been copied from any external sources, such as online tutorials or code. I have, however, relied heavily on two YouTube channels, those of Kevin Powell (Powell, 2025) and Coding2GO (Coding2GO, 2025), for guidance on best practices and inspiration.

No Generative AI was used in creating code for this project, but I did make extensive use of Google Search which automatically generates AI summaries that cannot be disabled. I partly mitigated this by using Google Scholar where appropriate which at the moment does not use user accessible AI. I also used Stack Overflow (Stack Overflow, 2025) to troubleshoot specific issues I encountered.

The automation tools used for testing accessibility and performance (Lighthouse, Axe, pa11y, Wave) are all open source tools developed by third parties and the scripts used to run them were adapted from examples found in their respective documentations and in online resources. I was assisted by a colleague at my employer, Transport for London, in writing the playwright tests used for testing browser compatibility.

7 Outstanding issues and Future Improvements

The project submitted for assessment is phase one of a larger project to refactor and improve the Web Witchcraft and Wizardry website. Some content was deliberately omitted from this phase as it will be developed in phase 2 using JavaScript. There are also some known issues and areas for improvement that could not be addressed within the time constraints of this phase.

Bug Id	Description	Symptoms	Work around
1	Reactive code does not work well at extreme viewport sizes	Text overflows boxes or content does not fill screen properly.	Warning displayed when viewport is too small.

Table 1: Known issues and workarounds

responsive design techniques Fluid grids, flexible images, and media queries (Marcotte, 2010) prefer responsive Viewport cutoffs < 80px too small – unusable 80px – 200px very small – give warning but still usable 200px – 800px small – mobile layout – prefer vertical stacking > 800px – desktop layout – prefer horizontal layout

accessibility features implemented

grid vs flexbox use of media queries semantic HTML ARIA roles and attributes colour contrast keyboard navigation alt text for images form accessibility

dry code (Hunt and Thomas, 1999)

8 Conclusion

Word count

Word count: 1112 words (excluding references)

References

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Appendices

A Folder tree of the Project

The following is the folder tree of the refactored Web Witchcraft and Wizardry project, showing the organization of files and directories. N.B. Folders in the git repository that are not relevant to this project are omitted (e.g., .github, tests).

```
. └── images
    ├── cat-1299082.svg
    ├── character-7371514_1920.png
    ├── evil-witch-9820120_1280.png
    ├── favicon.svg
    └── fontawesome
        ├── bat-duotone-light-full.svg
        ├── book-open-lines-duotone-regular-full.svg
        ├── book-spine-duotone-regular-full.svg
        ├── broom-duotone-light-full.svg
        ├── broom-wide-duotone-regular-full.svg
        ├── candle-holder-duotone-light-full.svg
        ├── cat-duotone-light-full.svg
        ├── cauldron-duotone-light-full.svg
        ├── cloud-bolt-sharp-duotone-light-full.svg
        ├── crow-duotone-solid-full.svg
        ├── dragon-duotone-thin-full.svg
        ├── dragon-solid-full.svg
        ├── flask-round-potion-duotone-light-full.svg
        ├── frog-duotone-regular-full.svg
        ├── hat-witch-sharp-duotone-regular-full.svg
        ├── hat-witch-solid-full.svg
        ├── hat-wizard-duotone-solid-full.svg
        ├── octopus-duotone-regular-full.svg
        ├── spider-duotone-light-full.svg
        ├── wand-magic-duotone-regular-full.svg
        └── wand-magic-sparkles-sharp-duotone-regular-full.svg
    ├── logo-embodied-mind-with-name-cyan.png
    ├── logo-embodied-mind-with-name-purple.png
    ├── michael-hamments-x6VyE3ie1sM-unsplash-landscape.jpg
    ├── michael-hamments-x6VyE3ie1sM-unsplash-portrait.jpg
    ├── rachel-mulligan-wiitch-old-male.jpeg
    ├── rachel-mulligan-witch-old-female.jpeg
    ├── rachel-mulligan-witch-young-female.jpeg
    ├── rachel-mulligan-witch-young-male.jpeg
    ├── rachel-mulligan-wizard-old-female.jpeg
    ├── rachel-mulligan-wizard-old-male.jpeg
    ├── rachel-mulligan-wizard-young-female.jpeg
    ├── rachel-mulligan-wizard-young-male.jpeg
    ├── witch-151167.svg
    ├── witch-4521410.svg
    └── wizard-36676.svg
    └── index.html
    └── mentors
```

```
pages
├── about.html
├── glossary-and-faq.html
├── license-and-credits.html
└── students.html
scripts
├── alert.js
├── footer.js
├── header.js
├── in-page-navigation-about.js
├── in-page-navigation-glossary-and-faq.js
└── in-page-navigation-license-and-credits.js
sitemap.xml
sitemap.xsl
students
styles
├── components
│   ├── buttons.css
│   ├── header-and-footer.css
│   ├── navigation.css
│   └── titles.css
├── main.css
├── media-queries
│   ├── about.css
│   ├── header-and-footer.css
│   ├── index.css
│   ├── license-and-credits.css
│   ├── navigation.css
│   ├── students.css
│   └── titles.css
│   └── noscript.css
└── pages
    ├── about.css
    ├── glossary-and-faq.css
    ├── index.css
    ├── license-and-credits.css
    └── students.css
```

B Test Outputs

This appendix contains the complete test results from the automated test suite. All tests were executed on December 18, 2025 and demonstrate compliance with web standards, accessibility guidelines, and readability requirements.

Summary of Test Results

Test Type	Metric	Result
Code Validation	Files validated	29
	HTML errors	0
	CSS errors	0
	JavaScript errors	0
Link Checking	Total links checked	161
	Broken links	0
	Pages checked	5
Axe Accessibility	Total violations	0
	Critical issues	0
	Serious issues	0
Lighthouse	Average score	100%
	Pages tested	5
	Failed audits	0
Pa11y Accessibility	Total errors	0
	Total warnings	0
	Pages tested	5
WAVE Accessibility	Total errors	0
	Alerts (non-critical)	10
	Pages tested	5
Reading Age	Average grade level	9.1
	Pages analyzed	3
	College-level pages	0
Browser Tests	Browsers tested	3
	Tests passed	150
	Tests failed	0

Table 2: Summary of all automated test results

Detailed Test Results

The following sections contain the complete JSON output from each test suite.

Code Validation Results

```
1 {  
2   "files": [] ,  
3   "summary": {  
4     "htmlErrors": 0,  
5     "htmlWarnings": 0,  
6     "cssErrors": 0,  
7     "cssWarnings": 0,  
8     "jsErrors": 0,  
9     "jsWarnings": 0  
10    }  
11 }
```

Broken Links Check Results

```
{  
  "pages": [  
    {  
      "url": "index.html",  
      "links": [],  
      "brokenCount": 0,  
      "totalCount": 19  
    },  
    {  
      "url": "pages/students.html",  
      "links": [],  
      "brokenCount": 0,  
      "totalCount": 40  
    },  
    {  
      "url": "pages/glossary-and-faq.html",  
      "links": [],  
      "brokenCount": 0,  
      "totalCount": 16  
    },  
    {  
      "url": "pages/license-and-credits.html",  
      "links": [],  
      "brokenCount": 0,  
      "totalCount": 36  
    },  
    {  
      "url": "pages/about.html",  
      "links": [],  
      "brokenCount": 0,  
      "totalCount": 45  
    }  
  ],  
  "summary": {  
    "totalLinks": 156,  
    "brokenLinks": 0,  
    "excludedLinks": 0  
  }  
}
```

Axe Accessibility Results

```
1 {  
  "violations": [] ,  
  "passes": [] ,  
  "incomplete": []  
}
```

Lighthouse Accessibility Results

```
{  
  "pages": [  
    {  
      "url": "index.html",  
      "score": 1,  
      "failedAudits": []  
    },  
    {  
      "url": "pages/students.html",  
      "score": 1,  
      "failedAudits": []  
    },  
    {  
      "url": "pages/glossary-and-faq.html",  
      "score": 1,  
      "failedAudits": []  
    },  
    {  
      "url": "pages/license-and-credits.html",  
      "score": 1,  
      "failedAudits": []  
    },  
    {  
      "url": "pages/about.html",  
      "score": 1,  
      "failedAudits": []  
    }  
  ]  
}
```

Pally Accessibility Results

```
1  {
2    "pages": [
3      {
4        "url": "index.html",
5        "documentTitle": "Web Witchcraft and Wizardry",
6        "pageUrl": "http://localhost:8080/",
7        "issues": []
8      },
9      {
10        "url": "pages/students.html",
11        "documentTitle": "Web Witchcraft and Wizardry",
12        "pageUrl": "http://localhost:8080/pages/students",
13        "issues": []
14      },
15      {
16        "url": "pages/glossary-and-faq.html",
17        "documentTitle": "Glossary and FAQ|Web Witchcraft and Wizardry",
18        "pageUrl": "http://localhost:8080/pages/glossary-and-faq",
19        "issues": []
20      },
21      {
22        "url": "pages/license-and-credits.html",
23        "documentTitle": "Web Witchcraft and Wizardry",
24        "pageUrl": "http://localhost:8080/pages/license-and-credits",
25        "issues": []
26      },
27      {
28        "url": "pages/about.html",
29        "documentTitle": "About|Web Witchcraft and Wizardry",
30        "pageUrl": "http://localhost:8080/pages/about",
31        "issues": []
32      }
33    ]
34  }
```

WAVE Accessibility Results

```
1  {
2    "pages": [
3      {
4        "url": "index.html",
5        "errors": 0,
6        "alerts": 2,
7        "features": 1,
8        "structural": 7,
9        "contrast": 0,
10       "errorItems": [],
11       "alertItems": [
12         {
13           "id": "h1_missing",
14           "description": "Missing first level heading",
15           "count": 1
16         },
17         {
18           "id": "noscript",
19           "description": "Noscript element",
20           "count": 1
21         }
22       ],
23       "contrastItems": [],
24       "waveUrl": "http://wave.webaim.org/report?url=https://crinkly-
25         majorie-dramatic.ngrok-free.dev/index.html"
26     },
27     {
28       "url": "pages/students.html",
29       "errors": 0,
30       "alerts": 2,
31       "features": 1,
32       "structural": 7,
33       "contrast": 0,
34       "errorItems": [],
35       "alertItems": [
36         {
37           "id": "h1_missing",
38           "description": "Missing first level heading",
39           "count": 1
40         },
41         {
42           "id": "noscript",
43           "description": "Noscript element",
44           "count": 1
45         }
46       ],
47       "contrastItems": [],
48       "waveUrl": "http://wave.webaim.org/report?url=https://crinkly-
49         majorie-dramatic.ngrok-free.dev/pages/students.html"
50     },
51   }
```

```

    "url": "pages/glossary-and-faq.html",
51   "errors": 0,
    "alerts": 2,
    "features": 1,
    "structural": 7,
    "contrast": 0,
56   "errorItems": [] ,
    "alertItems": [
      {
        "id": "h1_missing",
        "description": "Missing first level heading",
51       "count": 1
      },
      {
        "id": "noscript",
        "description": "Noscript element",
56       "count": 1
      }
    ],
    "contrastItems": [] ,
    "waveUrl": "http://wave.webaim.org/report?url=https://crinkly-
      majorie-dramatic.ngrok-free.dev/pages/glossary-and-faq.html"
71  },
  {
    "url": "pages/license-and-credits.html",
    "errors": 0,
    "alerts": 2,
    "features": 1,
    "structural": 7,
    "contrast": 0,
76   "errorItems": [] ,
    "alertItems": [
      {
        "id": "h1_missing",
        "description": "Missing first level heading",
        "count": 1
      },
      {
        "id": "noscript",
        "description": "Noscript element",
        "count": 1
      }
    ],
    "contrastItems": [] ,
    "waveUrl": "http://wave.webaim.org/report?url=https://crinkly-
      majorie-dramatic.ngrok-free.dev/pages/license-and-credits.html"
86  },
  {
    "url": "pages/about.html",
    "errors": 0,
    "alerts": 2,
    "features": 1,
91

```

```
101     "structural": 7,
102     "contrast": 0,
103     "errorItems": [],
104     "alertItems": [
105         {
106             "id": "h1_missing",
107             "description": "Missing first level heading",
108             "count": 1
109         },
110         {
111             "id": "noscript",
112             "description": "Noscript element",
113             "count": 1
114         }
115     ],
116     "contrastItems": [],
117     "waveUrl": "http://wave.webaim.org/report?url=https://crinkly-
118                 majorie-dramatic.ngrok-free.dev/pages/about.html"
119 }
```

Reading Age Analysis Results

```
1  {
2    "pages": [
3      {
4        "file": "./pages/students.html",
5        "wordCount": 514,
6        "fleschReadingEase": 65.2,
7        "fleschKincaidGrade": 8.9,
8        "smogIndex": 11.5,
9        "colemanLiauIndex": 8.8,
10       "automatedReadabilityIndex": 9.1,
11       "averageGradeLevel": 9.6,
12       "readingLevel": "Plain English (High School)",
13       "readingAge": "15-16 years"
14     },
15     {
16       "file": "./pages/glossary-and-faq.html",
17       "wordCount": 81,
18       "fleschReadingEase": 69.8,
19       "fleschKincaidGrade": 6.4,
20       "smogIndex": 10.3,
21       "colemanLiauIndex": 8.6,
22       "automatedReadabilityIndex": 6,
23       "averageGradeLevel": 7.8,
24       "readingLevel": "Fairly Easy (Middle School)",
25       "readingAge": "13-14 years"
26     },
27     {
28       "file": "./pages/about.html",
29       "wordCount": 1922,
30       "fleschReadingEase": 59.6,
31       "fleschKincaidGrade": 8.8,
32       "smogIndex": 11.4,
33       "colemanLiauIndex": 9.9,
34       "automatedReadabilityIndex": 8.5,
35       "averageGradeLevel": 9.7,
36       "readingLevel": "Plain English (High School)",
37       "readingAge": "15-16 years"
38     }
39   ]
40 }
```

Cross-Browser Compatibility Results

```
{  
  "browsers": [  
    {  
      "name": "chromium",  
      "status": "passed",  
      "error": null,  
      "tests": [  
        {  
          "name": "Home page title",  
          "status": "passed"  
        },  
        {  
          "name": "Home navigation links",  
          "status": "passed"  
        },  
        {  
          "name": "Home JavaScript execution",  
          "status": "passed"  
        },  
        {  
          "name": "Home CSS Grid",  
          "status": "passed"  
        },  
        {  
          "name": "Home CSS Flexbox",  
          "status": "passed"  
        },  
        {  
          "name": "Home CSS Variables",  
          "status": "passed"  
        },  
        {  
          "name": "Home SVG support",  
          "status": "passed"  
        },  
        {  
          "name": "Home responsive viewport",  
          "status": "passed"  
        },  
        {  
          "name": "Home CSS calc()",  
          "status": "passed"  
        },  
        {  
          "name": "Home font rendering",  
          "status": "passed"  
        },  
        {  
          "name": "About page title",  
          "status": "passed"  
        },  
      ]  
    }  
  ]  
}
```

```

{
  "name": "About navigation links",
  "status": "passed"
},
{
  "name": "About JavaScript execution",
  "status": "passed"
},
{
  "name": "About CSS Grid",
  "status": "passed"
},
{
  "name": "About CSS Flexbox",
  "status": "passed"
},
{
  "name": "About CSS Variables",
  "status": "passed"
},
{
  "name": "About SVG support",
  "status": "passed"
},
{
  "name": "About responsive viewport",
  "status": "passed"
},
{
  "name": "About CSS calc()",
  "status": "passed"
},
{
  "name": "About font rendering",
  "status": "passed"
},
{
  "name": "Students page title",
  "status": "passed"
},
{
  "name": "Students navigation links",
  "status": "passed"
},
{
  "name": "Students JavaScript execution",
  "status": "passed"
},
{
  "name": "Students CSS Grid",
  "status": "passed"
},
{

```

```

105         "name": "Students CSS Flexbox",
106         "status": "passed"
107     },
108     {
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