Black Box Accessibility Testing:

A Heuristic Approach

CAST 2015 Workshop Paper

Authors	
	Albert Gareev (agidale.info@gmail.com)
	Michael Larsen (mkltesthead@gmail.com)
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Problem Statement

In United States and parts of Canada, Accessibility is the hot topic because of the laws (Section 508[1], AODA[2]) and compliance deadlines that are coming up. Businesses are struggling in attempts to meet the compliance requirements both "in the letter and in the spirit". It is indeed tricky, especially for the Web Accessibility.

Often, software developers find themselves unfamiliar with the requirements model, given by Web Content Accessibility Guidelines (WCAG[3]). Product owners find holistic accessibility concept conflicting with feature-driven delivery approach. Testers are getting lost, too - there are no clear expected results they are used to verify.

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[1] Section 508 – Laws: http://www.section508.gov/section508-laws

[2] Accessibility for Ontarians with Disabilities Act: http://www.ontario.ca/laws/statute/05a11

[3] Web Content Accessibility Guidelines: http://www.w3.org/TR/WCAG20/

Users with Special Needs

How many people have disabilities or special needs? The numbers may surprise you. According to numbers presented by Sarah Horton and Whitney Quesenbery in their book "*A Web for Everyone*", The United Nations and the World Bank report that 650 million people worldwide have either a specific disability or combination of challenges. That's around one in ten people worldwide.

As part of the natural aging process, many of us will find that disability or special needs will affect us at some point. Additionally, we are conditioned to notice the significant disabilities, without realizing that there are a variety of special needs that are not so obvious. Below are some examples of special needs and disabilities.

Cognitive Disabilities

These include issues like autism, dyslexia and issues with processing information. These individuals may appear to be perfectly normal in many ways, until they try to read or process information. They may find large walls of text to be impenetrable.

Mobility Disabilities

A variety of disabilities fall into this area. Issues like cerebral palsy, multiple sclerosis and fibromyalgia all affect the physical operation of computers in some way. Some conditions are milder than others, but each of them has the same overall issue. Accessing the Internet and devices can require special devices to allow them to interface with the systems they use.

Visual Disabilities

There are a variety of visual issues that users may have to deal with. Issues like macular degeneration, color blindness, glaucoma, cataracts, and total blindness fall on the spectrum of visual disabilities.

Auditory Disabilities

Many users are dealing with significant hearing loss or total deafness. While this may seem to be a minor issue when it comes to text based sites, it's a significant use for sites that use audio or video as their primary method of transmitting information.

Second Level Disabilities

There are additional levels of "disability" or "special needs that we all face, and those are more aptly put into the realm of "secondary disability", which can be temporary, or a change in context, that could put anyone in a state where they are limited in their ability to do what they would normally be able to do. These situations could be entering an environment where the ambient noise overwhelms our ability to hear effectively, or to find ourselves in a country where the language is different than our own, or low light situations where our normal vision is compromised, or environments where our physical movements might necessarily be

constrained. How might we be able to access the information that we need and be effective at using it when we are in these situations?

Assistive Technologies

There are a variety of tools that can be used to allow users to interact with technology effectively. These range from external devices and special software that can make it possible to interface with systems, to software installed on systems to help enhance interactions. The other major success component is design and implementation of software so that it's better processed by assistive technologies and easier to understand and operate for users with special needs.

Assistance for people with Cognitive Disabilities

When it comes to cognitive disabilities, many of the issues can be solved with enlarging the text, hiding images, or allowing the user the ability to create macros and scripts of repetitive keyboard steps. The abilities to break up large blocks of text into smaller views are also helpful.

Accessible design helps to simplify information, reduce complexity of features, and improve overall usability and user experience.

Assistance for people with Physical Disabilities

Physical disabilities can cover a variety of issues, from ability to speak, to using one's hands or other limbs. Assistive devices can overcome many of these challenges. Some examples are using devices like a tablet that allows tough to enter information, microphone interfaces that allow users to speak commands, and special devices that allow users to map several commands to a single button press or joystick movements. For some extreme cases, there are systems that allow users to track movement of their eyes to issue commands and allow users to interact with systems.

Generally, the software must be fully operable through keyboard only to satisfy main criteria for assistance for people with physical disabilities.

Assistance for people with Visual Disabilities

The range of visual disabilities can range from slight visual impairment to complete blindness, and as such, devices that can allow users to interact with their systems can vary. Common tools for visually impaired users are screen readers (programs like JAWS, NVDA, and VoiceOver that audibly read out to the use what appears on the screen. Tools that record the voice and can convert those audible recordings to text are also helpful. In some cases, non-sighted users can also use devices that can display the text on the screen in braille, so that the user can touch the words. For less significant visual issues, making high contrast displays that can help differentiate between text and backgrounds, making text larger in an easy manner, or substituting different colors so that words will be visible to the user are also helpful.

Generally, the software must be fully usable with a screen reader to satisfy main criteria for assistance for people with visual disabilities.

Assistance for people with Auditory Disabilities

For those who have hearing impairment or total deafness, text communication may be easy to read for standard text sites, but interacting with other media like videos or real time voice communication creates a barrier to accessing information and communicating with others. Tools that allow the use of sign language, such as two way video communication and captions for audible sources are essential to being able to communicate and participate with others.

Web Accessibility

Formal definition

"***Web Accessibility*** *means that people with disabilities can use the Web. More specifically, Web accessibility means that people with disabilities can perceive, understand, navigate, and interact with the Web, and that they can contribute to the Web. Web accessibility also benefits others, including older people with changing abilities due to aging.*"[4]

Testers' clarifications (for the purpose of the workshop)

Accessible Web sites and applications are those that provide sufficient support of specific input and output required for users with special needs and assistive technologies they use. At the very least, users with special needs should be able to accomplish their goals using the web site or application while having no significant negative impact on their experience.

Accessible Web Page

Formal definition

"***Web Page*** *is a non-embedded resource obtained from a single URI using HTTP plus any other resources that are used in the rendering or intended to be rendered together with it by a user agent (any software that retrieves and presents Web content for users).* "[5]

Testers' clarifications (for the purpose of the workshop)

Web Page is what displayed in a browser or other user agent, has static contents or at least mainly static structure and relationships between the elements.

Formal definitions

"***Accessible*** *- accessibility supported by users' assistive technologies as well as the accessibility features in browsers and other user agents*"[6]

"***Accessibility Conformance*** *(and conformance level) is for full Web page(s) only, and cannot be achieved if part of a Web page is excluded.* "[7]

Testers' clarifications (for the purpose of the workshop)

Accessible –

- *meets explicit accessibility criteria to the <u>required or agreed upon</u> extent;*

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[4] Introduction to Web Accessibility: https://www.w3.org/WAI/intro/accessibility.php

[5] Web Content Accessibility Guidelines – Glossary: http://www.w3.org/TR/WCAG20/#glossary

[6] Web Content Accessibility Guidelines – Glossary: http://www.w3.org/TR/WCAG20/#glossary

[7] Web Content Accessibility Guidelines – Glossary: http://www.w3.org/TR/WCAG20/#glossary

- *"good enough" exploration was performed, and no accessibility problems were identified according to heuristic oracles.*

We will talk more about both criterions.

Note. Unlike with other software bugs, accessibility concept is holistic – all of issues on the web page must be fixed in order to make the page accessible.

Accessible Web Site and Web Application

Formal definition

*"A **website** is a set of related web pages."*[8]

*"**Complete processes**: When a Web page is one of a series of Web pages presenting a process (i.e., a sequence of steps that need to be completed in order to accomplish an activity), all Web pages in the process conform at the specified level or better."*[9]

Testers' clarifications (for the purpose of the workshop)

Web pages of the website have mostly static contents and links. Accessing pages is possible through hyperlinks and direct navigation to the page address. No particular data entry and form submission is required.

Web site is the entire product offered. Not just the part in the scope of the current release.

If an article is comprised of multiple web pages, any accessibility issue on any page impacts the whole article.

Formal definition

*"A **web application** is any software that runs in a web browser. It is created in a browser-supported programming language and relies on a web browser to render the application."*[10]

Testers' clarifications (for the purpose of the workshop)

Web application generates pages "on the fly". Page addresses are also dynamic, or it might be the same address for the sequence of pages. Authentication and data entry are required to navigate from page to page.

Web application is the entire product offered. Not just the part in the scope of the current release.

If a workflow is comprised of multiple web pages, any accessibility issue on any page impacts the whole workflow.

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[8] Wikipedia: http://en.wikipedia.org/wiki/Website

[9] Web Content Accessibility Guidelines – Glossary: http://www.w3.org/TR/WCAG20/#glossary

[10] Wikipedia: http://en.wikipedia.org/wiki/Web_application

Platform Specific Accessibility Aspects

Web technologies currently are actively evolving towards better support of accessibility. This includes development of Web standards for well-structured and semantically correct pages, built-in features for accessibility in frameworks and content platforms, and specific HTML tags and attributes that enable creation of fully accessible Rich Internet Applications(read more: ARIA[11])

Accessibility of Windows Desktop applications varies greatly depending on their generation and technology.

All latest versions of Apple iOS have a free built-in Screen Reader – VoiceOver – regarded as one of the best assistive technology products. Google works on development of similar free service on Android OS – Talkback. This puts mobile devices ahead of other platforms towards accessibility, both for Web-based applications and native mobile applications.

However, phones and tablets introduce accessibility challenges of their own. Smaller screen and text size, touch-based input that requires vision, cross-browser compatibility issues. Some of the challenges might be addressed by accessibility-friendly design. Others still require additional devices, like physical keyboard or Braille display.

Accessibility of Web Elements

Text

Assistive technologies can effectively pick and voice out text from HTML. They're also programmed to recognize text sectioning and formatting tags (to some extent) and spell accordingly.

The following aspects are ignored but might be distinguished by screen readers in the future:

- Basic formatting (bold, italic, underline, etc.)

- CSS formatting

The following aspects are recognized and have a strong use:

- Headings (H tags) – to support non-visual "scanning" of the page and navigation from section to section

- Hyperlinks – to support non-visual "scanning" of the page and navigation from section to section

- Tables – to properly spell tabular text according to structure and relationships

The following aspects are somewhat recognized and might be even better distinguished by screen readers in the future:

- Punctuation marks

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[11] Accessible Rich Internet Applications: http://www.w3.org/TR/wai-aria/

- Sectioning (division, paragraph) – to enable discrete (block by block) reading of text
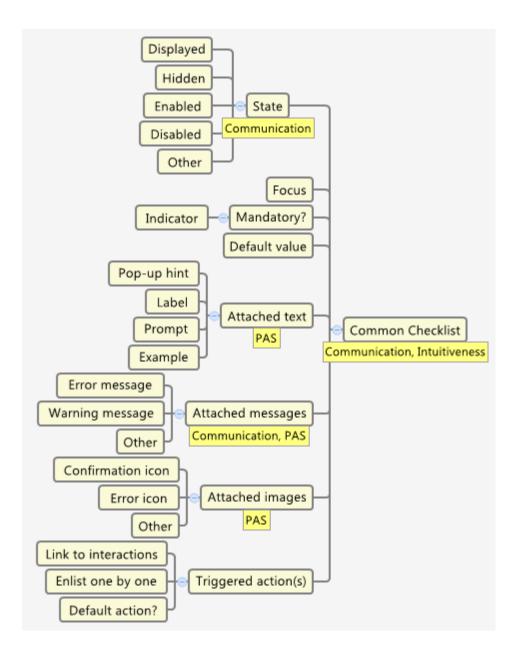
Images

Image, as a non-textual element, must be supplemented by custom textual description provided within @alt attribute. However, images used purely for visual formatting and decoration purposes must have @alt attribute with no text supplied to ensure that they're not spelled by screen reader.
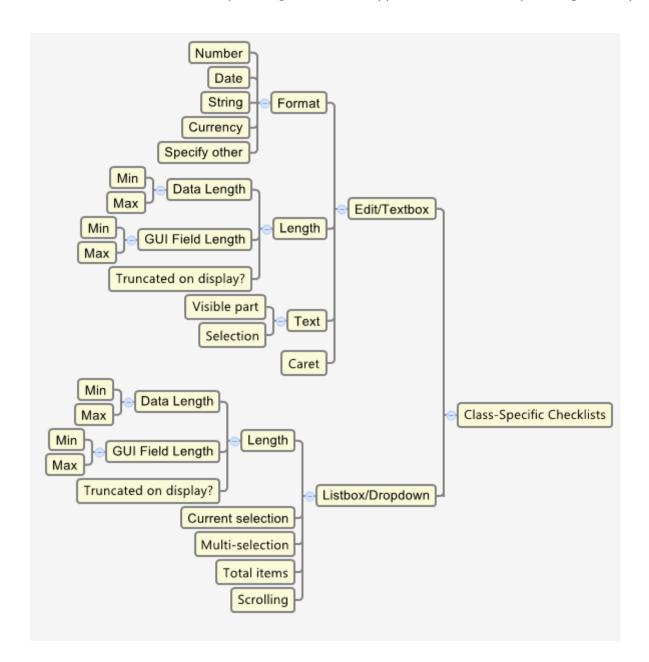
Simple GUI Controls

GUI controls recognized by assistive technologies as a specific type (edit, list, button, etc.) and also have recognizable properties that also need to be spelled. That is, if the accessibility support is properly implemented.

Mind map below provides a common checklist of properties that provide visual cues to the users and must be tested for auditory accessibility.

Depending on the class, GUI controls also have specific properties. Standard implementation usually is well-supported by assistive technologies. Custom implementation and custom properties must be properly encoded for support of accessibility.

Mind map below provides an example of class-specific checklists of properties.

Complex GUI Controls

Complex GUI controls, such as tables, are typically recognized by assistive technologies. However, providing additional textual descriptions (invisible to regular users) is recommended for better understanding of structure and relationships between the elements of complex GUI control.

Audio and Video Content

Audio content should be supplemented with visual alternative as text (captions).

Video content should be supplemented by audio description and text – subtitles or captions.

Animations and Live Content

Animations used for decorative purpose should be treated as decorative images. Otherwise, a paragraph of textual description is recommended to be provided – this text can be made invisible to regular users.

Live content (any parts of the page that update dynamically asynchronously from user actions or as a response to user actions) must be properly encoded to be detected by screen readers.

Decorative Content

Decorative content must be encoded so that it is ignored by screen readers – to avoid distractions.

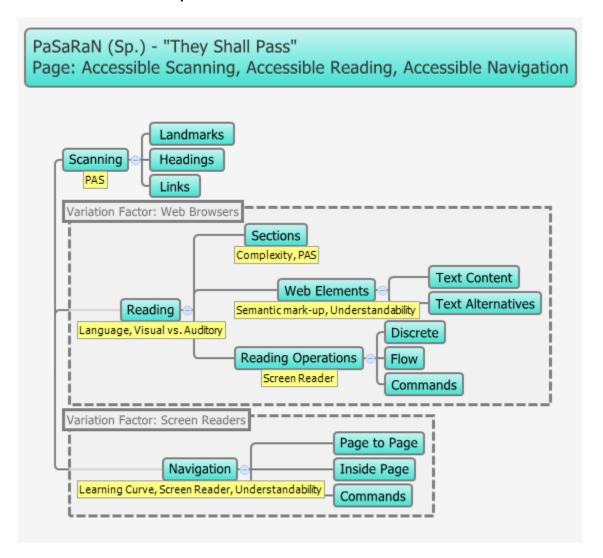### Accessibility Enablers: Landmarks and ARIA attributes

Landmarks serve the same purpose as headings, but they're not displayed on screen. Landmarks help non-sighted users to scan web pages and jump quickly to a desired part of the page.

ARIA (Accessible Rich Internet Applications) attributes is a special set of HTML attributes and tags that allow providing more information for assistive technologies that pass information to the users. This makes auditory information richer and more explanatory.

In case of custom GUI controls, ARIA attributes help to make them recognizable by assistive technologies and handled in the proper way.
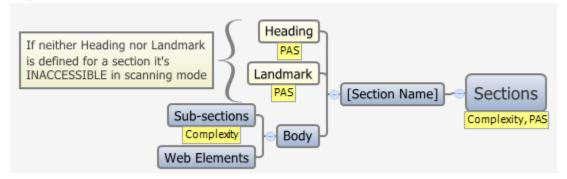
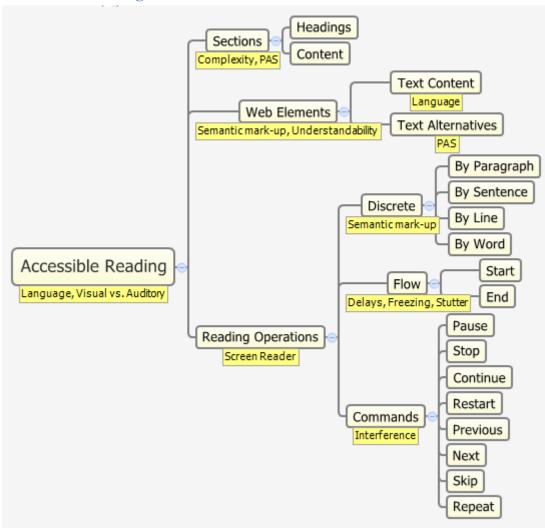## Accessibility Testing Techniques

Mnemonic and mind map

Accessible Scanning

Page Identification
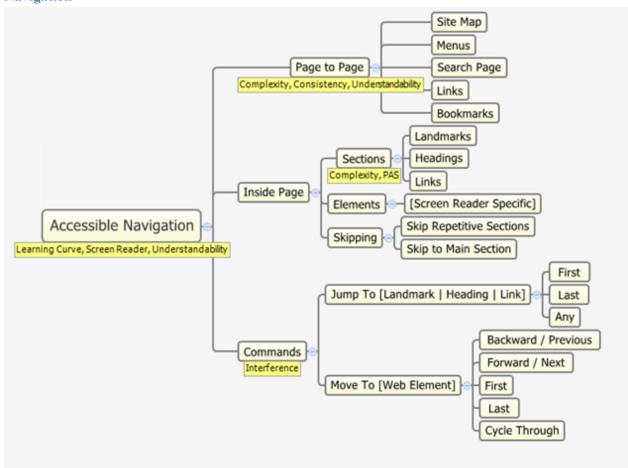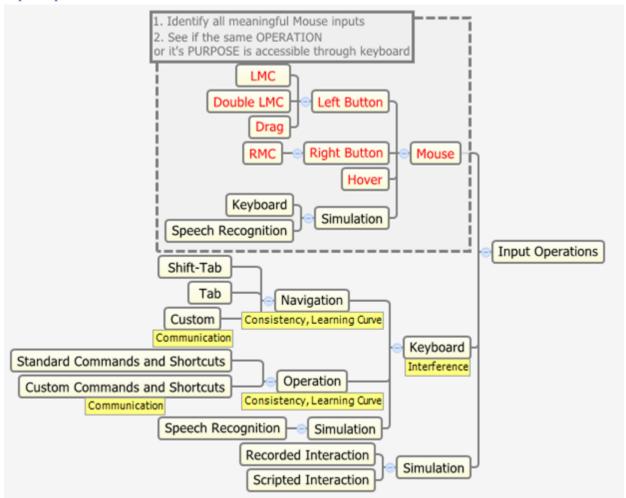

Page Structure

Accessible Reading

Accessible Navigation and Operation

Navigation

Input Operations

Heuristic Oracles

The concept of consistency oracles – heuristic principles that help to recognize a problem – is central in black-box testing and Rapid Software Testing[12]. Read more about oracles here[13] and here[14].

Technology Oracles

The following heuristic principles were brought as "technology oracles" due to close involvement of technology (either as implementation technology or as assistive technology) as the problem recognition mechanism.

Visual vs. Auditory

In general, whatever information is available on the visual perception channel must be consistent with what's available on auditory perception channel. More descriptions and hints might be available on auditory perception channel to compensate linearity of auditory stream.

All information and meta-information available through visual perception channel must be adequately provided through auditory channel with the help of assistive technologies. That includes, but not limited to – context details, text and its formatting (if it's used to highlight or alter the information conveyed), timing, and implicit information.

This heuristic oracle is used in close connection to "Semantic mark-up" and "Screen Reader" oracles.

Semantic mark-up

Visual appearance of the page elements must be consistent with their standard meaning.

Appropriate HTML tags and attributes should be used for headings, lists, tabular data, and web controls. If redefining elements is absolutely necessary, appropriate implementation must support the accessibility (such as explicit "name-role-value" encoding).

Screen Reader

Screen Reader tool is also the main accessibility testing tool and oracle. It allows testers to hear exactly what non-sighted users would hear, and to reproduce operations the same way as the users with specials needs do.

In general, web pages should be consistently handled with screen readers. That includes workaround implementation if the screen reader doesn't handle well the particular page implementation. Consistent handling includes Scanning, Reading, and Navigation modes.

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[12] Rapid Software Testing: http://www.developsense.com/courses.html

[13] Article on oracles by Michael Bolton: http://www.developsense.com/blog/2012/04/problems-with-problems/

[14] Article on oracles by Michael Bolton: http://www.developsense.com/blog/2012/04/all-oracles-are-heuristic/

There are some specific aspects highlighted as sub-oracles.

Interference

Web application keyboard commands must not be in the interference with browser and screen reader keyboard commands.

Delays, Freezing, Stutter

Web page contents should be implemented for consistent spelling with screen readers, without delays, freezing or stopping, and without "stutter" – repetition of words.

P-A-S: Present - Appropriate - Sufficient

A three step evaluation rule for accessibility features:

- A tag or attribute must be present in the HTML;

- It must be appropriate to the context and object class;

- Its value must sufficiently support accessibility.

Example – Image. The appropriate attribute must be present: @alt. Value of the attribute must be a text that sufficiently describes the image.

Complexity

In general, page complexity should not impact performance of web browser and assistive technology, as well as user's ability to navigate through the page.

Language

In general, written language of the page or its parts must be consistent with the spoken language of the screen reader.

Implementation must include encoding of the text language and setting of default language so that screen reader can recognize it and switch to the appropriate dictionary.

This oracle is closely connected to "P – A – S" oracle.

Psychology Oracles

The following heuristic principles were brought as "psychology oracles" as they're based on human perception and thinking processes used as the problem recognition mechanisms.

Memory

In order to understand or operate anything, people need to remember tacit information and rules. Human memory problem is one of special needs that accessibility must help with. This is also connected to cognitive abilities and special needs.

In general, amount of implicit and explicit memory requirements (i.e. how many things user needs to know and remember) should be consistent with the value of the information that user gains or the operation the user tries to accomplish. "Things to remember" include, but not limited to:

- Location of web elements on the page (non-sighted users cannot locate those easily);

- Remembering sequence of operations;

- Remembering data and data formats;

- Remembering keyboard shortcuts;

- Remembering abbreviations.

In general, things to remember need to be consistent with each other.

Examples. Navigation menu is always on the left. Order of links is the same. Similar operations have similar sequence of steps. Controls with the same meaning have the same labels describing them.

Understandability, Interpretation
In general, the information should be understandable and not misleading. The more complex information or workflow is, the more details should be provided. If users need to be aware of complex or irreversible steps, the information should be provided prior to that.

This oracle is connected to "Memory" – how much tacit knowledge user must have in order to understand and interpret correctly?

Learning Curve
In general, time to learn should be consistent with the value of the information that user gains or the operation the user tries to accomplish. Simple or little features should not be hard to learn for users with special needs. Similar functions should have similar interface and operations.

This oracle is connected to "Memory", "Understandability", and "Interpretation".

Common Oracles
The following heuristic principles were brought as "common oracles" as they're adopted from the general testing principles for problem recognition.

Consistency
Consistency is a family[15] of heuristic principles. The main are the following.

- History – we expect the present version of the system to be consistent with past versions of it.

- Comparable Products – we expect the system to be consistent with systems that are in some way comparable. This includes other products in the same product line; competitive products, services, or systems; or products that are not in the same category but which process the same data.

- Product – we expect each element of the system (or product) to be consistent with comparable elements in the same system.

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[15] Read more – FEW HICCUPPS: http://www.developsense.com/blog/2012/07/few-hiccupps/

- Purpose – we expect the system to be consistent with the explicit and implicit uses to which people might put it.

Complexity

Complexity is an oracle connected to "Learning Curve", "Understandability", and "Memory". The more complex web pages and workflows are, the harder is to learn and memorize it, the harder to navigate and operate, and the higher chances of making a mistake.

Time Spent

In general, time spent achieving the purpose should be worth it for users. If little things are hard to learn or achieve for users with special needs, then it's the accessibility problem.

This oracle is connected to "Learning Curve", "Memory", and "Complexity".

Communication

Communication is a set of heuristics for evaluation of relevance, consistency, and availability of information to the user.

The product should have consistent ways to inform the users "where" they are and what they can possibly do.

The product should have consistent ways to timely inform users about their actions, outcome, and errors – while prompting Screen Readers to notice and announce that for non-sighted users.

Finally, the communication itself should be consistent – use similar structures and style.