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UNIVERSITY OF SOUTHAMPTON

FACULTY OF PHYSICAL SCIENCES AND ENGINEERING

School of Electronics and Computer Science

**Automatically evaluating the mobile web accessibility of Higher Education
electronic texts for print impairments**

by

Neil Edward Rogers

Thesis for the degree of Doctor of Philosophy

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20th September 2019

UNIVERSITY OF SOUTHAMPTON

ABSTRACT

FACULTY OF PHYSICAL SCIENCES AND ENGINEERING

Computer Science

Thesis for the degree of Doctor of Philosophy

AUTOMATICALLY EVALUATING THE MOBILE WEB ACCESSIBILITY OF HIGHER EDUCATION ELECTRONIC TEXTS FOR PRINT IMPAIRMENTS

Neil Edward Rogers

The aim of this thesis is to investigate how to automatically evaluate the mobile web accessibility of Higher Education (HE) electronic texts for those with print impairments. The outcome is a master key component referred to as accessibility metadata. This unlocks hidden information that can be presented in human readable form and provides a means to automatically assess the accessibility support offered by mobile device settings, mobile browsers, ereader applications and downloadable formats. This process involves an academic or student searching for, finding, downloading, navigating and reading an electronic text while using a Higher Education Institute (HEI) library web portal on a mobile device. Two research questions are addressed using expert reviews. RQ1: determines four physical and sensory control categories, namely: visual, audio, touch and speech that support automatic evaluation. This also incorporates issues arising for those with dyslexia a form of cognitive impairment. The control categories analysed against user tasks, specific to searching for, finding, downloading, navigating and reading HE electronic texts provides the basis to answer RQ2. The latter investigates how automatic evaluation is achieved through the production of an instrument that provides Barrier Walkthrough (BW) success criteria. This criteria enables a specification to be written for a mobile web accessibility evaluation tool that is incorporated into a wireframe for four mobile web applications and a web service. In the future, the framework can be repurposed to other sectors, from pre-school tablet content to the use of adaptive mobile technologies by older adults who may experience age-related disabilities.

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Academic Thesis: Declaration of Authorship

I, Neil Edward Rogers

Declare that this thesis and the work presented in it are my own and has been generated by me as the result of my own original research.

Automatically evaluating the mobile web accessibility of higher education electronic texts for print impairments.

I confirm that:

1. This work was done wholly or mainly while in candidature for a research degree at this University;
2. Where any part of this thesis has previously been submitted for a degree or any other qualification at this University or any other institution, this has been clearly stated;
3. Where I have consulted the published work of others, this is always clearly attributed;
4. Where I have quoted from the work of others, the source is always given. With the exception of such quotations, this thesis is entirely my own work;
5. I have acknowledged all main sources of help;
6. Where the thesis is based on work done by myself jointly with others, I have made clear exactly what was done by others and what I have contributed myself;
7. None of this work has been published before submission.

Signed: 

Date: 20/09/2019

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I want to thank my family and friends for their unwavering support and encouragement throughout my doctorate, I could not have got this far without you.

University of Southampton, September 2019.

Definitions and Abbreviations

The abbreviations are provided first and the definitions then follow.

Abbreviations:

ADE: Adobe Digital Editions

AMP: Accessibility Management Platform

API: Application Programming Interface

AT: Assistive Technology

ATAG: Authoring Tool Accessibility Guidelines

BATA: British Assistive Technology Association

BDA: British Dyslexia Association

BIS: Business Innovation & Skills

BvD: Bureau van Dijk

BW: Barrier Walkthrough

BYOD: Bring Your Own Device

CASP: Critical Appraisal Skills Programme

CR: Conformance Review

CSS: Cascading Style Sheet

DRM: Digital Rights Management

DSA: Disabled Students Allowance

ED&I: Equality, Diversity and Inclusion

GA: Google Analytics

GARI: Global Accessibility Reporting Initiative

GPII: Global Public Inclusive Infrastructure

HAM: Harmonized Accessible Methodology

HE: Higher Education

HEI: Higher Education Institute

HESA: Higher Education Statistics Agency

HF: Human Factors

ICF: International Classification of Functioning

ICT: Information and communications technology

IDC: International Data Corporation

IDPF: International Digital Publishing Forum

IE: Internet Explorer

IRMA: Information Resources Management Association

LGS: Library GPII system

MWBP: Mobile Web Best Practice

NGO: Non-Governmental Organisation

NLP: Natural Language Processing

OCR: Optical Character Recognition

OER: Open Educational Resources

OPDS: Open Publication Distribution System

OS: Operating System

PDF/UA: PDF Universal Accessibility

PDF: Portable Document Format

PwD: People with disabilities

RDT: Resource Discovery Tool

RNIB: Royal National Institute of Blind

RQ1: Research question one

RQ2: Research question two

SC: Success Criteria

SIID: Situationally-Induced Impairments and Disabilities

SK: Subjective Knowledge

SMD: Social Model of Disability

SpLD: Specific Learning Disabilities (includes dyslexia)

SR: Screen Reader

STEM: Science, Technology, Engineering and Mathematics

SUSSED: The University of Southampton web portal

TTS: Text to Speech

UA: User Agent

UAAG: User Agent Accessibility Guidelines

UAIS: Universal Access in the Information Society

UBA: User Behaviour Analytics

UI: User interface

UKAAF: UK Association for Accessible Formats

UPIAS: Union of the Physically Impaired against Segregation

UPMC: L'université Pierre et Marie Curie

UWEM: Unified Web Evaluation Methodology

VI: Visual impairment

VLE: Virtual Learning Environment

VPN: Virtual Private Network

WAI: Web Accessibility Initiative

WCAG: Web Content Accessibility Guidelines

Definitions:

Academic publisher: produces both electronic and hardcopy publications, such as textbooks and journals for universities.

Access Mode Sufficient: is a single list of 'combined access modes that are sufficient to understand all the intellectual content of a resource' (W3C, 2018b).

Access Mode: is the 'The human sensory perceptual system or cognitive faculty through which a person may process or perceive information' (W3C, 2018b).

Accessibility barrier: as any condition that makes achieving a goal, when using a website through specific AT, problematic (Brajnik, 2006).

Accessibility evaluation tool: This is a tool that tends to be manually triggered by an accessibility specialist or evaluator that then tests automatically, for example, a website. For example, the Web Aim WAVE tool.

Accessibility feature: settings relating directly to accessibility, for example menu settings available on a mobile device or user agent that relate to accessibility.

Accessibility metadata: Accessibility metadata refers to machine readable tags within for example the PDF format that can be extracted. If a PDF that is tagged for accessibility it enables a screen reader user to be able to have text within the PDF

read aloud. If this information is extracted it can also be made humanly readable within an ereader application using Assistive Technology (AT).

Accessibility requirement: is the specific needs of a disabled person.

Accessibility supported: ‘Supported by users’ assistive technologies as well as the accessibility features in browsers and other user agents.’ (W3C, 2018a).

Adaptable (see also customisation): Adaptable systems allow a user to make manual changes to specific features (Benyon and Murray, 1993).

Adaptive (see also personalisation): Adaptive systems automatically make changes as it monitors the users’ interaction with the system during run time (Benyon and Murray, 1993).

Aggregator: aggregators provide licensed full-text content and work in tandem with publishers as content providers for libraries (Russell, 2018).

Alternative formats (Alt-formats): Alt-formats refer to the ‘transcription of books or other content (such as notes or newspapers or magazines) into a format other than standard print, i.e., large print, Braille, audio [and] talking books’ (AltFormat, 2016).

Application Programming Interface (API): ‘is a set of routines, protocols, and tools for building software applications [and] specifies how software components interact’ (webopedia, 2019).

Assistive Technology (AT): AT ‘is any product or service that maintains or improves the ability of individuals with disabilities or impairments to communicate, learn and live independent, fulfilling and productive lives’ (BATA, 2012). AT also enables disabled people to interact independently with mainstream technology and information (RNIB, 2018).

Authentication credentials: are a means of an institute providing a single login to multiple services, particularly for access to restricted or copyright material made available through, for example, a university library.

Authoring Tool Accessibility Guidelines (ATAG): ‘provides guidelines for designing web content authoring tools that are both more accessible to authors with disabilities [...] and designed to enable, support, and promote the production of more accessible web content by all authors [...]’ (W3C, 2015a).

Barrier Walkthrough (BW): is a method based on heuristic walkthrough evaluation that focuses on identifying accessibility barriers (Brajnik, 2006).

Basal-reading systems: The majority of ‘basal-reading systems offer a variety of materials for establishing sight vocabulary and for continuing word-perception practice [...]’ (Durrell, 1956).

Braille Display: is a device that enables small pins to move up and down that produce the Braille alphabet or numbers, typically using a six dot pattern.

ChemML: is a coding language that enables chemical annotations in, for example, a digital journal to be navigable by AT and read aloud by a screen reader.

Cognitive impairment: for the purposes of this thesis dyslexia, a form of cognitive impairment, was the only cognitive impairment addressed. See dyslexia.

Colour blindness: see colour vision deficiency.

Colour vision deficiency: ‘People with colour vision deficiency find it difficult to identify and distinguish between certain colours’ (NHS, 2019).

Conflict warning: occurs when an OS setting conflicts with the mobile ereader application setting.

Conformance Review: also referred to as Standards Review that requires an auditor to determine if accessibility criteria are met when comparing either a Web 2.0 service or application and a severity weighting is awarded. For example a severity weighting of 1, 2 or 3 (Brajnik, 2008). ‘1’ being inaccessible and ‘3’ being accessible with an intermediary stage being partially accessible.

Contextual menu: enables the user to access every accessibility setting available on a mobile device in one place. For example, the Android device has both a global and local context menu whereas the iOS devices have what is called Rotor.

Control categories: relate to the groups of user settings available either on, for example, a mobile device or user agent that determine functionality.

Coverage percentage: NVIVO was used to determine a coverage percentage indicating how much the source content was coded at a specific theme during Thematic Analysis.

Cross platform: means that, for example, a user agent can be used on any device.

Customisation (see also adaptable): Customisation refers to the ability of a user to be able to make manual changes to the features available on an interface (Schade, 2016).

Digital Rights Management (DRM): prohibits the exporting and importing of formats between third party ebook ecosystems (Bläsi and Rothlauf, 2013).

Disability type profiles: include user groups for cognitive, hearing, visual, communication received and producing, and upper limb impairments (Chalkia et al., 2009).

Disability: '[...] a physical or mental impairment that has a 'substantial' and 'long-term' negative effect on [the individuals] ability to do normal daily activities' (Crown, 2010).

Disabled Students' Allowance (DSA): The DSA 'are Student Finance grants [made available by the UK Government] that help to pay for extra Assistive Technology and Specialist Support that [students] may need as a direct result of [a] disability, on-going health condition, sensory impairment, mental-health condition or specific learning difficulty' (DSA, 2015, YourDSA, 2017).

Discovery: see resource discovery.

Dyslexia: is a disability that affects reading (Rello, 2014).

Ebook format: see eformat.

Ebook: is a digital book that can contain multimedia, such as video or audio files.

Ebookstore: is a collection of electronic books made available by a vendor such as the Amazon ebookstore.

Ecatalogue: is a collection of etextbooks, typically available within an academic or public library.

Econtent format: see eformat.

Econtent: is any form of digital content that can also contain images and other multimedia.

Eformat: is any digital file format such as a PDF or EPUB3.

Ejournal: is any form of digital journal.

Electronic text: see etext.

EPUB: This is the electronic publications format. The most current format is EPUB version 3.0 and is written as EPUB3.

Epublishation: is any form of digital content produced either by a publishing house or by an individual with the express reason for publishing the document.

Ereader: An ereader can be either a dedicated device, such as the Kindle Paperwhite, or a user agent.

Etext: is any form of digital text provided solely in the ASCII (plain text) format (Wexelbaum et al., 2011). For the purposes of this thesis the term is used because it has wider acceptance in the educational domain (Baron, 2014).

Etextbook: is the digital version of a textbook that may contain STEM subject matter.

False negative: are warnings of real issues in web accessibility evaluation (Bandeira et al., 2010).

False positive: are warnings of non-existent issues in web accessibility evaluation (Bandeira et al., 2010).

Fast web view: this is a metadata tag that enables a PDF to be viewed in a mobile browser.

Feature: is an setting available on, for example, a mobile device that relates to functionality.

Focus transition: occurs when moving focus from the device OS menus to the mobile ereader application menus

Functionality: as ‘processes and outcomes achievable through user action’ (W3C, 2018a).

Global Accessibility Reporting Initiative (GARI): provide an online database for accessible mobile devices and applications (GARI, 2018).

Global context menu: see contextual menu.

Hands on evaluation: is the physical testing of mobile devices (Whitehouse, 2011).

Heuristic Evaluation (HE): typically require an evaluator to comment on an interface design in accordance with relevant guideline rules (Nielsen and Molich, 1990).

Heuristic walkthrough: ‘is an effective task-oriented evaluation technique that is easy to learn and apply’ (Sears, 1997).

Hybrid application: Hybrid applications are ‘similar to web applications, but the outside is a native shell. Hence, the app[lication] runs within a native app[lication] framework rather than a browser’ (IRMA, 2017).

iOS: This is the operating system for Apple mobile devices.

Library collection: can be either a digital or hardcopy collection of books, for example, within a library.

Likert scale: is a means of measuring a response, such as an opinion for example, quantitatively through a scale from 1 – 5. A recognised scale is 1 (strongly

disagree) – 5 (strongly agree) where 3 is a neutral point. It is also sometimes referred to as a Likert item.

Local context menu: see contextual menu

MathML: is a coding language that enables mathematical annotations in, for example, a digital journal to be navigable by AT and read aloud by a screen reader.

Media queries: are responsible for enabling responsive web design and development, and enable a device to be interrogated, among other device properties, for screen resolution and size (Rivoal and Atkins Jr, 2015)

Medical Model of Disability: ‘The medical model of disability views disability as a ‘problem’ that belongs to the disabled individual. It is not seen as an issue to concern anyone other than the individual affected. For example, if a wheelchair using student is unable to get into a building because of some steps, the medical model would suggest that this is because of the wheelchair, rather than the steps.’ (UL, 2015)

Metadata: is data about data and is any form of tagging that enables a machine to recognise the semantic structure of a document for example. If implemented correctly metadata can also be made readable to humans.

Mobile accessibility: ‘[...] making websites and applications more accessible to people with disabilities when they are using mobile phones and other devices’ (WAI, 2016).

Mobile browser: are ‘[optimised] for [a] small [screen device] and [the] limited resources of a handheld computing device such as a smart phone’ (Rouse, 2018).

Mobile device: is usually a hand held device such as a smartphone or tablet. This thesis focuses only on the evaluation of smartphones.

Mobile first approach: is a paradigm that gave precedence to mobile devices over their desktop counterparts during the development phase.

Mobile web accessibility: the provision of appropriate mobile device accessibility features and the need to make mobile user agents, with support from web services, and downloadable electronic formats accessible to disabled people who need to perceive, understand, navigate to, interact with and contribute to mobile web content.

Mobile web application: Mobile web applications are ‘[...] accessed by [a] URL in a web browser (that runs on the mobile device) (IRMA, 2017).

Mobile Web Best Practice (MWBP): ‘[...] provides guidelines for assessing the usability of websites accessed on mobile devices’ (Rabin and McCathieNeville, 2008).

Motor impairment: this is a physical difficulty experienced by a person.

Native application: Native applications are ‘[...] designed and coded for a specific [type] of device [and] can usually be found in an app store, such as Google Play, and require the stores approval. They are downloaded from that store and installed on that device[...] and take advantage of the features of the operating system [...]’ (IRMA, 2017)

Open Access: is the provision of peer-reviewed academic literature and research made freely available online (OS, 2019).

Open Educational Resources (OER): ‘are teaching, learning and research materials in any medium – digital or otherwise – that reside in the public domain or have been released under an open license that permits no-cost access, use, adaptation and redistribution by others with no or limited restrictions’ (UNESCO, 2019).

PAC3: is a PDF accessibility evaluation tool that requires subscription for commercial purposes.

PAVE: is a PDF accessibility evaluation tool that requires subscription for commercial purposes.

Personalisation: (see also adaptive). Is where automatic changes are made by the system (Schade, 2016).

Pre-evaluation: is testing undertaken in preparation for full quantitative evaluation because it may be unclear what variables are required (Patton, 1987).

Print disability: is '[a] person who cannot effectively read print because of a visual, physical, perceptual, developmental, cognitive, or learning disability' (Kerscher, 2015).

Print impairment: is a person who has either a visual impairment (VI), including blindness; a motor impairment; a cognitive impairment, such as dyslexia; or a combination of these impairments. The person is disabled if they encounter barriers because no provision has been made for accessibility features when reading digital content or for alternative formats, such as Braille, when reading hard copy.

Programmatically determined: 'determined by software from author-supplied data provided in a way that different user agents, including assistive technologies, can extract and present this information to users in different modalities' (W3C, 2018a).

Resource Discovery Tool (RDT): This is the tool used in the process of searching for, finding and downloading academic electronic texts and is typically included on an HEI library collections website.

Resource discovery: is the process of searching for, finding and downloading academic electronic texts (Weibel, 1995).

Responsive web design: is an approach for designing websites that work in a range of different viewing contexts, from large desktop monitors to small mobile phones (Marcotte, 2010).

Rotor: see contextual menu.

SAGE: See academic publisher.

Screen reader: Screen reader's reads aloud all text content on the screen.

Search box: is an area where text can be input to search for a particular term, a good example of this is the Google search box.

Search metadata: enables a user to find information through the use of machine readable tags, typically this is used in libraries.

Sensus Access: is a tool that converts inaccessible digital content to accessible alternative formats (Christensen et al., 2012).

Situationally-Induced Impairments: ‘make it difficult for users of interactive computing systems to perform tasks due to context (e.g., listening to a phone call when in a noisy crowd) rather than a result of a congenital or acquired impairment (e.g., hearing damage)’ (Tigwell et al., 2019).

Social Model of Disability: is about people who are disabled by society because of barriers inherent in the physical world. For example, providing a ramp as opposed to steps for a wheelchair user removes the barrier.

Specific Learning Disabilities (SpLD): According to the British Dyslexia Association (BDA) an SpLD is an umbrella term that includes dyslexia (BDA, 2016).

Steady Tapping: is a problem that occurs for users with motor impairments particularly on small touch screen devices (Zhong et al., 2015).

Success Criteria (SC): are evaluation checklist items that meet specific requirements.

Switch access control: is a device used by those with physical difficulties or motor impairments, typically a round button that enables the user to select items using a part of their body if they are not able to use their hands for example.

Target size: is the touch area that may need to be resized (Zhong et al., 2015).

Text to Speech (TTS): TTS typically allows a user to select a block of text and have it read back aloud with either system voice or proprietary voice that is may be purchased through a mobile application.

Trade ebooks: are retail ebooks aimed at individual consumers (Whitney and Castell, 2017).

Universal Design: is the 'process of creating (devices, environments, systems and processes) which are useable by people with the widest possible range of abilities, operating within the widest possible range of situations (environments, conditions, and circumstances)' (Vanderheiden and Tobias, 1998).

Use case walkthroughs: These are the steps or tasks undertaken by a user to achieve a particular goal when using technology.

User Agent (UA): UAs can be an ereader application, mobile browser or media player.

User Agent Accessibility Guidelines (UAAG): 'guides developers in designing user agents that make the web more accessible to people with disabilities. User agents include browsers, browser extensions, media players, readers and other applications that render web content' (W3C, 2015b).

User Behaviour Analytics (UBA): devices enable information to be collected about what the user does but only if permissions are granted.

User stories: see wireframe.

Vendor: Typically this is a company that provides a service, such as Amazon or a publisher.

Virtual Private Network (VPN): provides online privacy and anonymity by creating a private network from a public Internet connection (Symantec, 2019).

Visual Impairment (VI): is when a person has limited optical vision.

Visual Stress: 'Visual Stress is a perceptual processing condition that causes reading difficulties, headaches and visual problems from exposure to patterns in text, such as lines of text. Visual Stress is linked to dyslexia and similar visual learning difficulties. Sufferers experience print distortion and fatigue when reading' (Eyesite, 2019).

Web accessibility: '[...] means that people with disabilities can perceive, understand, navigate, and interact with the Web, and that they can contribute to the Web' (WAI, 2005)

Web application: In most cases, a web app can be seen as a website that mimics a native app (IRMA, 2017).

Web Content Accessibility Guidelines (WCAG): is an internationally recognised set of guidelines that enable web content to be made more accessible to disabled people (Lewthwaite, 2014). The most current version is WCAG 2.1.

Web content: is 'information provided on the Web, such as text, images, and audio-visual media, as well as markup and code that control structure, presentation, and functionality' (Abou-Zahra et al., 2013).

Web portal: Is a website that enables access to multiple services in one location through a single sign on. For the purposes of this thesis it was only the HEI Library Web portal used at the University of Southampton, referred to as SUSSED, that was evaluated.

Web service: are software systems that are 'designed to support interoperable machine-to-machine interaction over a network' (W3C, 2004).

Web technology: 'technical specifications that are used to encode web content; for example HTML, CSS, SVG, etc..' (Abou-Zahra et al., 2013)

Wireframe: 'is a two-dimensional illustration of a page's interface that specifically focuses on space allocation and prioritization of content, functionalities available, and intended behaviours. For these reasons, wireframes typically do not include any styling, colour, or graphics. Wireframes also help establish relationships between a website's various templates' (UG, 2019).

Chapter 1 Introduction

The aim of this thesis is to investigate how to automatically evaluate the mobile web accessibility of Higher Education (HE) electronic texts for those with print impairments. The definition of print impairment, used throughout this thesis, came about as a product of the Social Model of Disability (SMD) and the existing definition of Print Disability. The SMD (Priestley et al., 1997) argues that people are disabled by society because of barriers inherent in the physical world. For example, providing a ramp as opposed to steps for a wheelchair user removes the barrier. This extends to products and services used by disabled people.

The definition for Print Disability (Kerscher, 2015), however, adopts a medical model approach whereby it is the individuals physical and/or cognitive impairments that prevents them from being able to read effectively. If, however, provision is made for features, such as those, that enable the user to alter text using an Assistive Technology (AT) this removes the barrier and meets their reading needs. The British Assistive Technology Association (BATA) state that AT *'is any product or service that maintains or improves the ability of individuals with disabilities or impairments to communicate, learn and live independent, fulfilling and productive lives'* (BATA, 2012).

The Royal National Institute of Blind People (RNIB) state that AT also enables disabled people to interact independently with mainstream technology and information (RNIB, 2018). Examples of AT include screen readers and Text to Speech (TTS), where a screen reader reads aloud all text content on the screen; whereas TTS is used to select and read aloud specific blocks of text by the user.

For example, an individual with dyslexia who has perfect vision may have issues with acquiring meaning when reading complex textual information. If an accessibility feature is provided that allows this individual to refer to synonyms on demand (Rello and Baeza-Yates, 2014) this removes the barrier. Print impairment is therefore defined, for the purposes of this thesis, as a person who has either a visual impairment (VI), including blindness; a motor impairment; a cognitive impairment, such as dyslexia; or a combination of these impairments. The person is disabled if they encounter barriers

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because no provision has been made for accessibility features when reading digital content or for alternative formats (alt-formats), such as Braille, when reading hard copy.

Print impairments have parallels with Situationally-Induced Impairments (Sears et al., 2003), for example an individual may find it difficult to read text onscreen because of bright sunlight. The same maybe true for an individual struggling to read hardcopy text in a glossy magazine because of glare. If a user is able to alter the brightness onscreen this may alleviate issues with ambient lighting conditions. The same maybe said if an alt-format such as matt paper is provided in a magazine thereby reducing glare. According to Yesilada et al situational impairments, such as viewing text on a mobile device screen in bright sunlight, have been included in the accessibility evaluations of small screen devices (Yesilada et al., 2011). This thesis fully maps print impairments to situational impairments based on recent published research findings.

Dedicated technology exists that enables text to be read under direct sunlight without requiring the use of brightness controls, such as the Amazon Kindle Paperwhite. This thesis, however, concentrates only on mobile devices, specifically smart phones. The accessibility features available as settings on mobile devices and User Agents (UAs), such as mobile browsers and ereader applications led to a needs based approach. This focused on the accessibility requirements of users with print impairments and introduces the first of four target stakeholders.

Firstly, the academic or student user (Whitehouse, 2011) who has a print impairment may encounter barriers preventing them from searching for, finding, downloading, navigating and reading HE electronic texts. An example of a barrier experienced by the user maybe the amount of time (Whitehouse, 2011) allowed when reading an electronic text that has been encrypted using Digital Rights Management (DRM). These electronic texts may be core or critical reading material essential to the user's education or research.

Searching for, finding and downloading academic electronic texts, typically referred to as Resource Discovery (Weibel, 1995), may take place through a Higher Education Institute (HEI) library web portal on a mobile device using a mobile browser. Institute portals tend to be a website that through a single login, referred to as authentication, enables a student and/or academic to gain access to multiple online services offered by the

institute. For example, one of the services is likely to be access to the institute's library catalogues that may include restricted access to copyrighted material provided by academic publishers. The academic or student may then download an electronic text onto their mobile device and then use an ereader application to read the downloaded PDF or EPUB format.

Inherent to this process is the need for the user to be able to navigate through the HEI library web portal, the academic publisher or academic aggregator's website, the mobile device and the UA. For example, a screen reader user may need to move focus, usually indicated by a rectangular outline box denoting an area of interest during navigation, using swipe gestures on a mobile device. The process from discovery to reading an electronic format requires that each stage is accessible to the academic or students AT as suggested by McNaught et al. (2010).

Secondly, academic librarians in HEI libraries (Whitehouse, 2011) are investigating the accessibility of Resource Discovery Tools (RDTs) and the use of accessible search metadata as referred to by Beyene and Godwin (2018). One of the key components of these tools is the use of a search box that relies on search metadata to enable a user to find a specific electronic text. Although HEI libraries are addressing the accessibility of their platforms (Whitehouse, 2011) there is a problem, in that they rely on academic publishers and academic aggregators to provide accessible electronic formats, such as the PDF and EPUB without the means to check automatically.

Thirdly, academic publishers (Whitehouse, 2011), particularly larger publishing houses such as SAGE Publications, are making concerted efforts to address accessibility as stated by McNaught and Alexander (2014). However, McNaught maintains that academic publishers rely on accessibility requests from HEI librarians in order to determine demand (McNaught, 2016b). There is also the issue that the majority of academic publishers currently use EPUB2 (Alexander, 2017), a format that does not support the accessibility features available in the EPUB3 format.

This suggests there is an element of catch up required since the majority of ereader applications provided by vendors support the new EPUB3 format as referred to by Kasdorf (2017). In order to aid academic publishers in this endeavour the ACE EPUB3

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accessibility evaluation tool is currently available. Another problem encountered by academic publishers is ensuring the accessibility of PDFs, particularly complex PDFs containing STEM content, when a single electronic text collections subscribed to by HEI libraries may contain over 60,000 documents such as that available from Ebrary. Vasileiou et al provide evidence that libraries prefer the PDF format because of the text linking and search capabilities that are easy to use (Vasileiou et al., 2012a). Automatic PDF accessibility evaluation tools exist, such as PAC3 and PAVE but these require subscription for commercial purposes and are limited in the complexity of the PDF document they can process. Also certain aspects of the PDF format need to be manually evaluated, including the reading order of the content and colour contrast.

Finally, academic aggregators (Whitehouse, 2011) operate in tandem with academic publishers as content providers for HEI libraries providing licensed full-text digital content as stipulated by Russell (2018). Russell states too that there is also a tendency by aggregators to offer web based discovery (Russell, 2018). In addition to this the accessibility of ebook platforms, produced by aggregators, requires involving the academic publishers in a process that prevents the development of isolated solutions for these platforms, as suggested by Whitehouse (2011). This thesis develops this line of reasoning and extends it into preventing isolated mobile web accessibility evaluation.

It follows that the stakeholders who provide a service have a remit of responsibility for accessibility in their own domain and that this must not be undertaken in isolation. For example the institute library is responsible for the accessibility of its own web portal platform, whereas the academic publisher and academic aggregators are responsible for the accessibility of the digital content they supply to HEI libraries. In addition to this, both the academic publisher and academic aggregator are responsible for the accessibility of their own websites that the HEI library, through authentication credentials, enables academics or students to access. In each case these stakeholders need to be aware of how the mobile web accessibility specific to their domain can impact across the entire supply chain. It is for this reason that one of the main tenets of this thesis is to provide a mobile web accessibility evaluation tool that enables stakeholder interaction.

The demand for the accessibility evaluation tool as developed in this thesis is based on four factors. First and foremost, the risk of litigation under the Equality Act 2010 (Crown, 2010) and The Public Sector Bodies (Websites and Mobile Applications) (No.2) Accessibility Regulations 2018 (Kingdom, 2018) is a pressing concern for HEI libraries. Particularly as the deadline for public sector websites is the 22nd September 2020 and public sector mobile applications is 22nd June 2021 (GDS, 2018). This also demonstrates the importance of this research and one of the key reasons why it is not only essential but urgent.

Second, Hassell states that the prevalence of disabilities within developed economies, that could impact the use of digital products and services, is on average approximately 20%. This ranges from '12%' to as much as '26%' depending on the figures that are analysed (Hassell, 2015). According to the Higher Education Statistics Agency (HESA), the prevalence of print impairment in UK Higher Education for students during 2017/18 was 5.48% who have disabilities that are related to print impairments (HESA, 2019); although this figure is likely to be higher because of undisclosed disabilities. These figures demonstrate not only the business case for accessibility in this domain but also the demand for such a tool.

Third, preventing isolated mobile web accessibility evaluation by the HEI libraries, academic publishers and academic aggregators warrants the development of an automatic accessibility evaluation tool. This is the case particularly as the number of electronic texts available in this domain are significant. In addition to this, there is the consideration of how the accessibility provision of each stakeholder has a direct and significant impact on the level of digital accessibility available to each academic or student in HEIs. Since there is a disconnect between the accessibility request rates sent by HEI librarians and received by academic publishers (McNaught, 2016b), there is also a demand for tangible figures. It is likely that academic aggregators working in tandem with academic publishers would also benefit from being able to automatically evaluate the mobile web accessibility of their websites, ereader platforms and electronic formats.

Finally, Mune and Agee state that there is an increasing prevalence in electronic texts within HEI library collections (Mune and Agee, 2016). The preference for the PDF format

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by HEI librarians (Vasileiou et al., 2012a) is metred by advocates for the accessible EPUB3 format, not only from academic research (Bläsi and Rothlauf, 2013) but also the publishing domain as stipulated by Kasdorf (2017). Bläsi and Rothlauf state that alongside unilateral agreements for DRM solutions vendors need to also be willing to alter ereader applications for the same purpose (Bläsi and Rothlauf, 2013). Russell suggests that this may be encouraged by contractual obligations that specify accessibility requirements (Russell, 2017).

Delcker et al maintain that mobile device usage in Higher Education is also increasing alongside particular emphasis on student needs, and how these mobile devices may best facilitate those needs (Delcker J. et al., 2018). This re-emphasises the needs based approach of this research. In addition to this HEIs are favouring Bring Your Own Device (BYOD) policies (Draffan et al., 2014) over the unsustainable use of institute devices. The predominant use of the iPhone in a UK HEI (Deeprise, 2016) reflected the March 2015 – September 2015 trend in the UK for the Android device being superseded by the iPhone as indicated by Statista (2019). However, according to Statista since March 2019 the Android Operating System (OS) has regained its dominant position in the UK (Statista, 2019). Statista state that globally the Android smartphone was the most dominant in the second quarter of 2018 (Statista, 2018). It should be noted that according to Microsoft the Windows 10 mobile will no longer be supported after December 10, 2019 (Microsoft, 2019).

The journey of the user in the real world relates to Equality, Diversity and Inclusion (ED&I) within an HEI environment. This is governed by policies within an institute to ensure implementation of directives. Typically these policies adhere to basic rights for both staff, academic researchers, and the student community. According to an example statement made by the University of Southampton website this culture is fostered throughout the institute with the intention of preventing discrimination, including but not limited, to aspects such as disability, age, sex, race, religion and belief, marriage and civil partnership (UoS, 2019).

This thesis concentrates on preventing disability discrimination by addressing the accessibility barriers encountered by academic or student users with print impairments

reading electronic texts via an HEI library web portal on a mobile device. This is undertaken against the backdrop of the changing accessibility landscape caused by changes made to the Disabled Students' Allowance (DSA). The DSA are student grants issued by the UK government that provide funding for essential AT and accessible resources that meet accessibility requirements of the student. These tend to be based on an assessment undertaken by Enabling Services within an institute.

Changes made to the DSA (Underwood, 2014) are impacting institutes who have a responsibility to make provision for the type of assistance referred to in the Equality Act 2010, instead of relying on the DSA funding. According to Draffan financial contributions for technology options may not be fully covered by the DSA requiring institutes to make improvements to alt-format provision. In addition to this, financial reductions altering the accessibility landscape are impacting the users, organisations and practitioners across the HE sector (Draffan, 2014).

This research helps the academic or student, HEI librarian, academic publisher and academic aggregator to identify accessibility issues and also proposes a solution. This is achieved through the use of four web applications and a web service that enable stakeholder interaction. For example, if an academic or student user encounters a format, either a PDF or EPUB3, that is inaccessible this can be flagged. Remedial action can then be taken by the HEI library involving both the academic publisher and academic aggregator if required. One of the key features of this service is that it is presented in stakeholder appropriate language, a feature that was corroborated in the comments made during expert reviews of a prototype.

The academic or student user may be aware that they need to alter a particular setting on their device or in an ereader application, such as altering text and background colour, but maybe unaware that this relates to accessibility. The academic or student user web application also provides the means to be able to undertake ereading.

In addition to this, the other feature incorporated across all four stakeholder specific web applications is a tool that enables mobile web accessibility evaluation. This is a tenet developed throughout this thesis that culminated in a proof of concept tool that enabled the extraction of accessibility metadata from a PDF. Accessibility metadata refers to

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machine readable tags within the PDF format that can be extracted. For example, a PDF that is tagged for accessibility enables a screen reader user to be able to have text within the PDF read aloud. If this information is extracted it can also be made humanly readable within the web application using Assistive Technology (AT). The British Assistive Technology Association (BATA) state that AT is any form of technology that enables a disabled person to improve or maintain their ability to communicate with others, to live independently, learn and to lead fulfilling productive lives (BATA, 2012).

The proposed solution in this thesis is a tool that enables the automatic extraction of all available accessibility metadata across mobile devices, User Agents (UAs) and electronic texts, in particular the PDF and EPUB3 formats. This is with the intention of making this accessibility metadata humanly readable by all stakeholders. The UAs are specific to mobile browsers and mobile ereader applications that can open both the PDF and EPUB3 formats. The mobile browsers used in this research were cross platform and the ereaders predominantly operate across the three mainstream mobile OS platforms at the time of writing. This was deliberately undertaken in order to be inline with the Web Content Accessibility Guideline (WCAG 2.1) tenet of a technology neutral approach (W3C, 2018) to mobile web accessibility evaluation.

In doing so this also prevents isolated evaluation across the entire HEI library mobile web ecosystem, specific to reading electronic texts for those with print impairments. The provision of a web service was also deliberate within this thesis, in that this enables a database to be generated for every aspect of available accessibility metadata in this ecosystem. The web service supports each web application and in turn the accessibility metadata extracted by each web application, as a data stream, updating the web service. The web service itself was also designed to be separate from a repository that maps to existing web accessibility and mobile guidelines. This was inline with research undertaken by Arrue et al. (2007). Arrue et al incorporate accessibility from the outset through the use of a web service that has a separate repository for accessibility guidelines (Arrue et al., 2007). According to Arrue et al this feature enables new and or updated guidelines to be incorporated into the automatic mobile web accessibility evaluation tool without impacting the code (Arrue et al., 2007).

The other important aspect of automatic evaluation is to extract accessibility metadata that exposes the extent of accessibility evaluation that have already been undertaken by the academic publisher and academic aggregators. For example, the academic publisher may undertake manual tests on the electronic format that can be indicated within the accessibility report included the format. In the PDF format these currently relate to whether the academic publisher or academic aggregator has manually checked the PDF for colour contrast or reading order. Reading order is important because, where it has not been checked, a screen reader user may, for example, find the footnotes being read aloud in the middle of a paragraph.

The mobile web accessibility evaluation tool and the four web applications were designed based on the outcome of success criteria generated by an instrument as demonstrated in this thesis. This instrument incorporated a framework that integrates the mobile device. The instrument and framework provide a means to distinguish between accessibility metadata that is already available and for accessibility metadata that can be developed in the future. This research also exposes areas where accessibility metadata is available within ereader applications that, for example, support synonyms on demand for those with dyslexia, but this provision is not currently supported in mobile browsers or as a feature on mobile OS's. Although a metric, to measure accessibility support, was also included in the instrument it was not the purpose of this research to validate this provision. The purpose for this investigation was therefore a demonstration of how to use accessibility metadata, a framework, instrument and prototype.

Another important aspect of this research is that it does not rely on third party device description repositories. These types of repositories were referred to by Vigo et al. (2008). This research is comparable to that undertaken by Vigo et al in that it enables evaluation for mobile web browsers and ereader applications. It then exceeds this by introducing the evaluation of electronic formats, specifically the PDF and EPUB3. In addition to this research it also enables actual device settings to be automatically evaluated.

1.1 Research Gap

Task orientated evaluation alongside expert review has been used, according to Billi et al, to test the accessibility and usability of an evaluation tool that provides suitable applications for different mobile devices (Billi et al., 2010). What has not been addressed, as yet, are the user task success criteria required for discovery, downloading, navigating and reading etexts in the HEI mobile web ecosystem for those with print impairments.

Beyene undertook accessibility evaluations on RDTs and within search metadata, identifying barriers for disabled users (Beyene, 2016). The potential for accessibility metadata and its availability across the entire HE etext ecosystem for print impairments is not addressed in the evaluations undertaken on RDTs and search metadata. For example, accessibility metadata is not just available for search metadata aiding discovery, but is also available for the automatic detection of accessibility features available to mobile devices, mobile web browsers, mobile web content, mobile user agents as ereaders and econtent formats, such as a PDF and EPUB3. This is undertaken through (Application Programming Interface (API) calls. According to webopedia an API *'is a set of routines, protocols, and tools for building software applications [and] specifies how software components interact'* (webopedia, 2019).

Although accessibility evaluations have been undertaken for dedicated ereader hardware devices, such as the Amazon Kindle Fire and the Barnes and Noble Nook tablet (Maatta and Laurie, 2014) this is beyond the remit of this thesis. Nevertheless, this could be addressed in the future through a mobile web accessibility evaluation web service that enables the accessibility support for dedicated ereading devices to be determined.

Although manual crowdsourced HEI ebook accessibility audits exists in the UK (McNaught, 2016a) and for reading systems (Luceno, 2014), the system proposed by Vanderheiden et al. (2014) offers automatic accessibility evaluation aimed at libraries. This system does not, however, fully address the issues of print impairments, particularly those that arise from cognitive impairments such as dyslexia. It is for this reason that the how of automatically evaluating mobile web accessibility of HE etexts for print impairments needs to be determined.

Requests have been made for further research into the mobile web accessibility domain for mobile devices and in particular for the integration of device characteristics into guidelines that support mobile web accessibility evaluation and best practice as suggested by Kaur and Dani (2017). However, device characteristics have previously been incorporated into automatic mobile web accessibility evaluation tools by Vigo et al. (2008).

Although heuristic checklists have been investigated for smartphone interface design, by focusing on sensory and physical control categories (Mi et al., 2014), there is no known heuristic checklist that provides similar control categories for a mobile web accessibility evaluation tool in the HE etext ecosystem for print impairments. It is for this reason that physical and sensory control categories will need to be determined for mobile web accessibility evaluation in this context. The term ‘checklist’ used here can also be referred to as an ‘instrument’, and it is this latter term that will be used throughout the remainder of this thesis.

In addition to this, disability type profiles and accessibility requirements as specified by Chalkia et al. (2009) have also been made available for older adults, cognitive impairments, physical and sensory impairments, and small device users as suggested by Yesilada et al. (2009). This begins to address the request, by Abou-Zahra et al, to determine what accessibility requirements there are for each of the web components, such as evaluation tools and user agents, given that the roles have shifted in the mobile context (Abou-Zahra et al., 2013). Yesilada et al suggest that User Agents (UAs) are not only accessed by AT but also by mobile devices (Yesilada et al., 2011). It does not, however, consider the integration into an instrument specifically addressing automatic mobile web accessibility evaluation for print impairments in the HE etext domain. For example, users who have dyslexia, a specific type of print impairment and cognitive impairment, may require text customisation (Henry, 2012), a decluttered screen, Text to Speech (TTS) (Rello and Barbosa, 2013), Read Along or simplification, such as synonyms on demand (Rello and Baeza-Yates, 2014). These features would perhaps be categorised within an audio and visual control category.

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Abou-Zahra et al emphasise the extent to which mobile devices support accessibility features within the mobile web accessibility domain (Abou-Zahra et al., 2013). Bandeira et al. suggest that automatic mobile web accessibility evaluation tools also help support the design and development of UA's (Bandeira et al., 2010).

The mobile web accessibility evaluation methodologies used across the entire HE etext ecosystem, also predominantly focused on visual impairment only, this shortfall is beginning to be addressed by research within the physical difficulties (Trewin et al., 2013, Zhong et al., 2015) and dyslexia (James et al., 2017) domains. One major issue with the current provision of these methodologies is that mobile web accessibility evaluations are undertaken in isolation and need to be combined under a single framework and instrument.

In addition to this, even though a scoring system has been proposed for the accessibility of etextbooks (Chan et al., 2017), a scoring method is required across the entire HE etext ecosystem for print impairments. This will enable the accessibility support for not only mobile devices, but mobile web browsers, mobile web content, mobile web user agents and downloadable etext formats, namely the PDF and EPUB3 to be determined. The term 'score' can also be referred to as a metric, and it is this latter term that will be used throughout the remainder of this thesis.

1.1.1 Scope

The research in this thesis focuses solely on investigating how to automatically evaluate the mobile web accessibility of HE etexts for those with print impairments. The outcome of this is an instrument that identifies the accessibility metadata that can be automatically detected across mobile devices, mobile browsers, ereader applications and downloadable formats, namely the PDF and EPUB3. This also includes the detection of accessibility features available on institute web portals through the use of accessibility metadata.

The following indicates where this research is situated in the wider research domain. For example, mobile web usability is an area of research that is related to mobile web accessibility, but is beyond the remit of this thesis. Mobile web usability is an area of research that is rapidly growing (Al-Ismael and Sajeev, 2014) and includes usability

evaluations in the HE mobile domain as referred to by (Hegarty and Wusteman, 2011). Dedicated ereaders, such as the Amazon Kindle Fire and Nook have also been evaluated for print disabilities (Maatta and Laurie, 2014) but with over 200 dedicated hardware ereading devices available in the mainstream ebook market place (DePriest, 2016) this is also currently beyond the remit of this thesis.

The use of tablet technologies outside of HE, but still within the educational sector are also currently beyond the scope of this thesis. For example, from preschool, relating to mark making (Neumann, 2016) and the development of fine motor skills by children (Lin et al., 2017), to older adults engaged in life long learning as suggested by Sharples (2000). This would also include mobile pedagogy, m-learning and ubiquitous learning (Sharples et al., 2016), alongside the use of Open Educational Resources (OERs) (Gráinne and Pascual Pérez, 2018) within a mobile context.

Five other areas that are currently beyond the scope of this thesis, but that are directly relevant, include the accessibility of:

1. Personalisation through adaptive interfaces for older adults as referred to by both Sloan et al. (2010) and (Gonçalves et al., 2017).
2. Multimedia content, such as captioned videos, in ebooks;
3. Science, Technology, Engineering and Mathematics (STEM) content in the EPUB3 format as stipulated by Gylling and Herman (2014).
4. Annotations in etexts, and how these relate to the Authoring Tool Accessibility Guidelines (ATAG 2.0);
5. Automatically providing alt-text for image descriptions through the use of Natural Language Processing (NLP) (Bigham, 2007). Alternatively the reuse of alt-text descriptions by using reverse image search (Guinness et al., 2018) could also be included within the framework.

Although Digital Rights Management (DRM) provides technological protection of copyright, this thesis will not be addressing the laws of copyright (CLA, 2010) or development of policies within the HEI library domain (Whitehouse, 2011) and other related treaties (WIPO, 2013), because these issues have already been substantially covered by others.

1.2 Research questions

Since it was necessary to determine what physical and sensory control categories were required, alongside how the mobile web accessibility of HE etexts for print impairments need to be automatically evaluated, two research questions were addressed, namely:

RQ1: What physical and sensory control categories support automatically evaluating the mobile web accessibility of Higher Education electronic texts for print impairments?

RQ2: How does the mobile web accessibility of Higher Education electronic texts for print impairments need to be automatically evaluated?

Answering RQ1 will also need to incorporate evaluating issues arising for those with dyslexia, dovetailing with research in the cognitive impairment domain by the Cognitive and Learning Disabilities Accessibility Task Force (Coga TF) COGA (2017b) and (COGA, 2017a). The physical and sensory control categories analysed against user tasks, specific to searching for, finding, downloading, navigating and reading HE electronic texts for those with print impairments provides the basis for answering RQ2. The latter investigates how automatic evaluation is achieved through the production of an instrument and metric that provides a specification that automatically measures accessibility support using accessibility metadata. This then enables the use of a heuristic walkthrough combined with an independent expert review.

1.3 Research contributions

The main research contribution of this thesis is the provision of a rationale for using mobile web accessibility metadata and its future development. This accessibility metadata can be programmatically determined across mobile devices, mobile browsers, ereader applications and downloadable formats, such as PDFs and EPUB3s within an HEI library ecosystem and goes beyond the accessibility evaluation of search metadata.

Two other research contributions in this thesis are a framework and an instrument that provides automatic Barrier Walkthrough (BW) success criteria. This enabled a specification to be written and for a wireframe to be designed for the development of an

automatic mobile web accessibility evaluation tool. If the instrument is integrated into the design and development lifecycle of third party device features and UAs it has the potential to enable accessibility to be embedded at source. It also has the potential to enable the control of accessibility for in-house ereader applications developed for or by a specific stakeholder. For example, enabling an academic publisher to determine demand for accessible digital publications.

Minimising the number of control categories and HEI library mobile web user task evaluation steps aids stakeholder adoption. The outcome was an automatic means to evaluate the mobile web accessibility of HE etexts for print impairments. The framework integrates mobile devices, institute library web portals, mobile web UAs, and downloadable formats, specifically PDF and EPUB3, through the use of a master key component, namely accessibility metadata.

This research contribution is significant because it not only integrates the device characteristics as implemented by Vigo et al. (2008) but also contributes to updating the 10 year old Mobile Web Best Practice (MWBP 1.0) a request made by Kaur and Dani (2017). It also has the potential to determine the accessibility support for mobile device features (Abou-Zahra et al., 2013). In doing so, this prevents isolated accessibility evaluation across the HEI library mobile web ecosystem for etexts read by those with print impairments. The key accessibility requirements for print impairments within the HEI library etext mobile web ecosystem for print impairments are also determined.

This is further supported by the identification of four physical and sensory control categories that group mobile device settings and incorporate features that address some of the issues faced by those who may have dyslexia or other specific reading difficulties. The control categories are then analysed against user tasks identified through an end to end heuristic walkthrough of the HE etext ecosystem. Additional careful research minimised the number of control categories and mobile device features required for evaluation. Similarly, the number of user tasks were also reduced to a minimum with the intention of improving stakeholder adoption of the instrument and metric. There are, however, limitations to this in that there was a trade off between the number of reduced components and the granularity of the instrument to detect the availability of

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accessibility metadata. The research also helped to address the deficit between the number of visual impairment studies and the existing research that covers motor impairment and dyslexia.

The specification, produced from the instrument, enabled a proof of concept prototype to be developed that extracts accessibility metadata from a PDF successfully without requiring proprietary software such as Adobe Acrobat Standard. Although non-proprietary platforms exist to evaluate the accessibility of PDFs, such as PAVE and PAC3, these tools have not been integrated into a web service that supports the entire HE etext ecosystem for print impairments. Future iterations, at the time of writing, of the tool will be able to evaluate the EPUB3 format based on the relevant International Digital Publishing Forum (IDPF) standard. The IDPF is combining with the W3C for strategic reasons (IDPF, 2017).

The extraction of accessibility metadata from a PDF through the aforementioned web service was the highest priority for the first iteration. This included the provision of a specification to develop a proof of concept prototype.

Wireframes were also used to support the development of the instrument to ensure that all task based steps had been covered in the heuristic walkthrough of the entire mobile web accessibility evaluation of HE etext delivery for print impairments. The wireframes were high fidelity prototypes (Van Velsen et al., 2008) created using a prototyping tool developed by Invision. The Invision application enables realistic interaction of the desired mobile interface based on screenshots linked by image maps. The wireframes also helped identify the significant number of steps that print impaired academics or students are required to undertake in order to search for, find, download, and interact with HE etexts. This corroborates the findings of McNaught et al. (2010).

The development of the wireframes enables the future development of four web applications. The academic or student web application will allow ereading to take place alongside stakeholder interaction between this application and those designed for the HEI library, academic publisher and academic aggregator. It will also enable the full exposure of accessibility metadata from within an institute version of the application or free version in human readable form.

1.4 Thesis structure

Chapter 2: Background. A systematic approach to the review of the literature and research material is adopted for this chapter rather than a full systematic literature review as referred to by Booth et al. (2012). The reason for this is that the argument presented in this treatise does not rely solely on the outcome of the literature review. It is also supported by evidence from an expert review and a physical assessment of mobile devices and manual testing of ereader applications, mobile browsers and eformats. In doing so this captures all possible nuances within the domain, through triangulation, that could be missed by a full systematic review of the published research findings alone. The chapter is divided into two main sections that deals with mobile web accessibility and HE etexts for print impairments.

The core components of mobile web accessibility are explored, alongside mobile accessibility and automatic web accessibility evaluation. This includes identifying the need to update the 10 year old Mobile Web Best Practice version one (MWBP 1.0). This then brings mobile web accessibility evaluation methodologies to the fore and emphasises the need to address the deficit between studies that focus predominantly on evaluating visual impairment and those that do not. Heuristic evaluation and walkthrough are discussed in conjunction with automatic accessibility evaluation tools, alongside the evaluation methodologies adopted for web services and mobile UA's. Mobile device accessibility evaluations are also discussed emphasising physical and sensory control categories alongside guidelines for the design of mobile ICT devices (ETSI, 2016) and their related applications for cognitively disabled people. This leads to existing methodological frameworks that address cognitive, physical and sensory impairments for small device users and the general accessibility constraints for this user group interacting with small screen devices.

HE etexts for print impairments are then investigated distinguishing between HE and non-HE electronic text ecosystems. The reason for this is important because it helps to determine if this research is able to make a contribution within non-HE sectors, such as preschool through to older adults engaged in lifelong learning. The differences between etext, ebook and etextbook are then considered alongside adoption of mobile devices,

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ereaders and etexts in HE. Mobile device usage is also considered within HE. Print impairment and its prevalence within HE, in the UK, is also discussed identifying key accessibility requirements for print impairments. Existing accessibility evaluation methodologies are then investigated for different components within the mobile web HE etext ecosystem for print impairments. These inform the development of an instrument and metric that uses the core component, namely: accessibility metadata. This chapter concludes with a summary.

Chapter 3: Methodology. In order to answer RQ1 an inductive approach using physical assessment of mobile devices is used, alongside BW, a form of heuristic evaluation, for academics and students alike. The use case is specific to an HEI libraries mobile web portal. This informed the development of an expert review that determines the physical and sensory control categories that meet the accessibility requirements for those with print impairments. Answering RQ2 requires an independent expert review of the instrument before it is used to manually to assess the accessibility support for mobile devices and mobile UA's. In doing so this tests the success criteria of the instrument and provides a verifiable means to produce a specification for an accessibility evaluation tool that is supported by a web service. This chapter concludes by providing an overview of chapters four, five, six and seven.

Chapter 4: Identifying physical and sensory control categories. This chapter provides each stage of how RQ1 is answered and the design of the methods used in the research. It starts with the design of the testing stages that support Expert Review One. This includes how the mapping of core accessibility settings across mobile devices and UA's alongside academic and student use case walkthroughs is to be undertaken. This was important because the use case walkthroughs provided general accessibility requirements for print impairments specific to the HEI library mobile web ecosystem. It exposes the number of potential accessibility barriers for print impairments that could be encountered when reading etexts in this ecosystem and are referred to as user tasks. Once this was established, the core accessibility settings are mapped that carry the findings of the use case walkthrough to three mainstream devices, namely the Android, iOS and Windows mobile devices. The chapter also provides a detailed explanation of how Expert Review

One is to be undertaken by referring to the use of a survey and Thematic Analysis. The chapter then concludes with a summary.

Chapter 5: Physical and sensory control categories results and discussion. Chapter five identifies 24 core technology neutral accessibility settings across mobile devices and UAs. These are then mapped to both physical and sensory device control categories and five new framework components. The five new framework components are corroborated in this chapter based on an adaptation of the Ebook Access Bridge Model as referred to by McNaught et al. (2010).

This is then followed by determining the relevance to Higher Education Institute (HEI) ereading for specific accessibility features. The support for the PDF and EPUB3 formats enables a shortlist of mobile ereader applications to be started. This is culled further by determining which ereader applications supported the three main mobile OS's at the time of writing.

The core technology neutral accessibility settings are then mapped across 10 ereader applications, three cross platform mobile browsers and three online readers. This provides a list of 23 settings supported by over half of the ten ereader applications. It also highlights the limited accessibility features available to the mobile browsers and conversely the 70 accessibility features available to both the Radium and the Bureau Van Dijk online readers.

The outcome of these mappings enables academic and student use case walkthroughs to be undertaken. The use case walkthroughs are critical and determined the total number of potential barriers based on print impairment type against five new framework components. Each of these potential barriers relates to the user tasks undertaken for the framework components.

Expert Review One uses Thematic Analysis as the primary means of evaluation, and the qualitative statements made by the individual expert reviewers are cross referenced against the subjective knowledge and actual expertise of the participants. The outcome of this is four physical and sensory control categories, integrating the device into the five new framework components. In addition to this, the user tasks referred to previously are

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also mapped to the framework components with the emergence of a new instrument and metric. The results are discussed and then followed by the limitations of the review and the chapter concludes with a summary of the findings.

Chapter 6: Development of the instrument. This chapter illustrates how each stage of RQ2 is answered. As with chapter four this chapter focused on the design of the tests and determined the method for Expert Review Two. The testing stages were designed to determine that each component of the instrument is robust. It is realised that for the development of the instrument a careful search through existing guidelines and standards, and online API libraries is required. This is to determine if the accessibility metadata for both the PDF and EPUB3 formats could be programmatically detected alongside the accessibility support provided by API's across the HEI library mobile web ecosystem.

Chapter 7: Instrument results and discussion. Expert Review Two analysed two key Likert type questions. These questions related to whether the automatic BW success criteria for each user task would work on an HEI's library web portal, and again for an academic publishers website. The results suggest that although the research is heading in the right direction further analysis is still required. The most significant finding, however, is the discovery of a turn key component referred to as accessibility metadata that can unlock hidden information and make it humanly readable from within a mobile application. In addition to this, chapter five also indicates how the automatic mobile web accessibility framework is updated during the course of the research. Once again, in this chapter limitations of the review are discussed and the chapter concludes with a summary of the findings.

Chapter 8: Specification and wireframe. Chapter eight also contributes to how RQ2 is answered. The outcome of chapter's four to seven provided a framework and an instrument and metric that generated automatic BW success criteria that enabled a specification to be written for a mobile web accessibility evaluation tool. This also provides the first iteration of a proof of concept tool, coded by a developer at the University of Southampton. The proof of concept demonstrates that accessibility metadata can be extracted from a PDF as part of a web service. The mobile web

accessibility evaluation tool is then incorporated into four separate web applications and a web service. The outcome of this is a wireframe for a high fidelity prototype and walkthrough that is reviewed during Expert Review Two based on the automatic BW success criteria. The chapter describes the stakeholder interaction that is provided by the prototype and emphasises each stakeholder's perspective in this context, particularly in terms of implementing a common language between the stakeholders. This is particularly relevant to the four mobile web applications and how these are supported by a web service. The limitations of the specification and wireframe are discussed and the chapter concludes with a summary bringing together different aspects of the specification.

Chapter 9: Conclusion and future work. The conclusion provides a breakdown of the main research contribution, namely accessibility metadata, and how this relates to RQ2. It also explains why RQ2 could not be answered until RQ1 is answered. It then goes on to explain how RQ1 is answered and then discusses the relationship of Expert Review One findings with previous published research findings. The limitations of Expert Review One are then discussed. This is followed by how RQ2 is answered with an emphasis on the results from two Likert scale questions that determine whether the automatic mobile web accessibility evaluation criteria would work on an HEI library mobile web portal and an academic publisher's website. The relationship of Expert Review Two findings with previous published research findings is then discussed. The limitations for Expert Review Two are provided alongside concluding remarks about the specification and wireframe. The chapter then concludes with a future work section that explains how the research could be scaled up to non-HE environments but remaining within the educational sector.

Chapter 2 Background

The aim of this thesis is to investigate how to automatically evaluate the mobile web accessibility of HE etexts for those with print impairments. Clegg-Vinell et al argue that embracing a fully a user centred approach to mobile web accessibility evaluation is a challenge (Clegg-Vinell et al., 2014). Bandeira et al suggest that this is because of the range of diverse disabled user characteristics, the ongoing evolution of mobile and web content accessibility guidelines, mobile device and UA updates and developments (Bandeira et al., 2010). Arrue et al state that the breadth and complexity of these dimensions necessitates that automatic mobile web accessibility evaluation is an integral and essential part of the process (Arrue et al., 2007).

This research is important because Higher Education Institutes (HEIs), in the UK, risk litigation under the Equality Act 2010 (Crown, 2010) if service provision, as stipulated by GOV.UK, is not made accessible to all academics or students that require it (GOV.UK, 2017). In addition to this, at the time of writing, the European standard EN 301549, in section (42) of the European Union (EU) Directive 2016/2102, specifies '*the functional accessibility requirements for ICT products and services, including web content*' and state that this may be implemented in public procurement or to support other legislation and policies (Europa, 2016). It mandates that member states implement the directive for public sector body websites and mobile applications to be reviewed by mid 2022 (Europa, 2016). Subsequent to this the EU directive has now become legislation in UK law and according to GOV.UK, compliance for existing websites is required by 23 September 2020 (GOV.UK, 2018). Abou-Zahra states that EN 301 549 has also adopted the Web Content Accessibility Guidelines (WCAG 2.1) (Abou-Zahra, 2018).

According to the Public Sector Equality Duty, Section 149 of the Equality Act 2010 (Crown, 2010), as highlighted by JISC, HEIs must proactively anticipate the requirements of disabled people requiring access to and participation in tertiary education activities (JISC, 2013a). JISC states that reasonable adjustments are also required under Section 20, of the above act, that must not disadvantage, for example, a disabled person through inaccessible institute service provision (JISC, 2013b). Section 20 (6), relating to

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information provision, expressly states that information is made available in an accessible format as emphasised by JISC (2013b).

If mainstream formats, such as PDFs or EPUBs are not accessible, then HEI libraries may provide alternative formats (more commonly referred to as alt-formats within this domain). AltFormat state that alt-formats refer to written materials that are transcribed into other formats such as talking books, audio, large print and Braille (AltFormat, 2016). When an academic or student undertakes a search to find and download an etext, it is likely they will use a Resource Discovery Tool (RDT). This process is integral to this thesis for searching for and finding published research.

2.1 Published research findings search strategy

The two research questions, RQ1 and RQ2, focus on identifying control categories and how automatic evaluation takes place within the mobile web accessibility HEI library ecosystem for those with print impairments. Relevant published research findings, that included evaluation methodologies, were sought using four stages. These stages were recommended by Dybå and Dingsøyr, for a search strategy of the background chapter to determine relevant studies in this domain:

‘Stage 1: Identify relevant studies - search databases and conference proceedings (n=273).

Stage 2: Exclude studies on the basis of titles (n=176)

Stage 3: Exclude studies on the basis of abstracts (n=150)

Stage 4: Obtain primary papers and critically appraise studies’ (n=86)
(Dybå and Dingsøyr, 2008).

The values for (n) denote the number of relevant studies identified at each stage. Please refer to Appendix A for a breakdown of the search strategy. In total 1,397 studies were found during the review undertaken for the background chapter for this thesis. The data sources included 11 academic databases that were searched within the date range 2010 – 2018, namely:

1. Google Scholar

2. ACM Digital Library
3. Compendex
4. ePrints Soton
5. Espacenet
6. IEEE Xplore
7. INSPEC
8. Lecture Notes In Computer Science (LNCS)
9. Proquest
10. Scopus
11. Web of Science Core Collection

The reason this specific date range was chosen is that, according to the University of Liverpool, by the end of 2009 ebooks had seen a dramatic and accelerated growth in the marketplace (UoL, 2010). Additional ad hoc searches were also undertaken for papers before 2010. Through this process canonical papers were discovered either directly or indirectly by investigating the references of papers written by recognised authors relevant to this domain. In this way additional studies were also found, such as those relating to physical and sensory control categories for interface design by Mi et al. (2014). Four search combinations were used, namely: A, B, C and D. Please see Appendix A for the full list of permutations that were searched under. Any duplicates in this list were then deleted and rationalised for use on a spreadsheet for further analysis.

The following search terms were used in the review:

A = "mobile web accessibility"

B = "higher education"

C = "electronic text" OR "etext" OR "e-text" OR "etextbook" OR "e-textbook"

An additional search was undertaken for the search terms:

"electronic book" OR "ebook" OR "e-book"

The reason for this was that certain academic search engines did not allow extended search strings and the search terms had to be kept to a minimum. This also highlighted

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the need to use the term 'e-book' in journal paper keywords to help with finding this particular research.

D = "print impairment" OR "print impaired" OR "print disability" OR "print disabled"

The keywords 'automatic' and 'evaluation' were picked up by the phrase 'mobile web accessibility' and so were not included in the search. For example, searching for 'mobile web accessibility' returned within the results the paper title *Automatic Evaluation of Mobile Web Accessibility* authored by Arrue et al. (2007). Based on an abridged version of the Critical Appraisal Skills Programme (CASP) systematic review methodology for Stage 3, three main criteria, as recommended by Dybå and Dingsøyr, were assessed for quality:

1. 'Rigour. Has a thorough and appropriate approach been applied to key research methods in the study?
2. Credibility. Are the findings well-presented and meaningful?' This included whether the papers were peer reviewed and that they appeared in recognised journals or conference proceedings.
3. 'Relevance. How useful are the findings to the software industry and the research community?' (Dybå and Dingsøyr, 2008)

The 86 shortlisted studies resulted in:

19 Conference papers
16 Conference proceedings
46 Journal articles
4 Theses
1 Patent

The predominant journal being the Universal Access in the Information Society (UAIS) and for conference proceedings the Web 4 All (W4A). Once shortlisted, the studies were then divided into two main categories:

1. Mobile web accessibility, including evaluation methodologies; and

2. Higher Education electronic texts for print impairments, also including relevant evaluation methodologies.

2.2 Mobile web accessibility

The Web Accessibility Initiative (WAI), overseen by the World Wide Web Consortium (W3C), define mobile accessibility as: *'[...] making websites and applications more accessible to people with disabilities when they are using mobile phones and other devices'* (WAI, 2016). The WAI also state that web accessibility *'[...] means that people with disabilities can perceive, understand, navigate, and interact with the Web, and that they can contribute to the Web'* (WAI, 2005).

Although no official definition could be found, mobile web accessibility is therefore defined for the purposes of this thesis as: the provision of appropriate mobile device accessibility features, and the need to make mobile UA's such as mobile browsers and mobile applications, with support from web services, and downloadable electronic formats accessible to disabled people who need to perceive, understand, navigate to, interact with and contribute to mobile web content.

Eight essential components of mobile web accessibility have been identified by Abou-Zahra et al and together they facilitate an end-to-end process of accessibility from the design and development through to use by the end user, namely:

1. *'Web content;*
2. *Web technologies;*
3. *Authoring tools;*
4. *Evaluation tools;*
5. *Developers;*
6. *User agents (UA's);*
7. *Assistive Technology (AT); and*
8. *Users'* (Abou-Zahra et al., 2013).

Abou-Zahra et al. state that the Web Content Accessibility Guidelines (WCAG 2.0), and WCAG 2.1; the User Agent Accessibility Guidelines (UAAG 2.0); the Authoring Tool

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Accessibility Guidelines (ATAG 2.0) are essential components of mobile web accessibility. Clegg-Vinell suggest too that the Mobile Web Best Practice (MWBP 1.0) are also essential components (Clegg-Vinell et al., 2014). According to Lewthwaite WCAG 2.0 is an internationally recognised set of guidelines that enable web content to be made more accessible to disabled people (Lewthwaite, 2014). According to the W3C it enacts universal principles that provide testable technology agnostic Success Criteria (SC) (W3C, 2008). Kelly et al, state that WCAG 2.0 is technology agnostic based on the core principles that the web is perceivable, operable, understandable and robust (Kelly et al., 2009).

The W3C state that WCAG 2.1 has recently become a recommendation but does not replace or supersede WCAG 2.0 (W3C, 2018). WCAG 2.1 addresses specific aspects of cognitive impairments and learning disabilities with current work as specified by COGA (2017a) undertaken by the Coga TF. Nielsen maintains that the usability of a system requires that it is *'easy to learn'* and *'easy to remember'* (Nielsen, 1993) and may help within the context of cognitive impairments.

Williams and Hennig found that the position of navigation menus appeared to be more effective when they were horizontal as opposed to vertical, with the most essential information provided on the left side of the screen. Williams and Hennig also state that there are design implications for websites based on the consumption of information in a serial manner for those with cognitive impairments (Williams and Hennig, 2014).

The Web Content Accessibility Guidelines (WCAG) addresses the accessibility support provided by mobile devices, tablets, laptops, and desktops for web content rendered by ATs and used by disabled people (W3C, 2015b). In addition to this Vigo and Harper refer to *'accessibility in use'* and how this can be evaluated on the Web (Vigo and Harper, 2013) but do not explain how this would be accommodated within a mobile context.

The W3C state that UAAG 2.0 *'guides developers in designing user agents that make the web more accessible to [disabled people]. [UA's] include browsers, browser extensions, media players, readers and other applications that render web content'* (W3C, 2015c). Whereas ATAG 2.0 *'provides guidelines for designing web content authoring tools that are both more accessible to authors with disabilities [...] and designed to enable, support, and promote the production of more accessible web content by all authors [...]'* (W3C, 2015a).

Abou-Zahra et al argue that there is a strong overlap between mobile and web accessibility, but that the more general web content accessibility guidelines do not distinguish between the two domains, and further research is required in this area (Abou-Zahra et al., 2013). Abou-Zahra et al, query three aspects of mobile web accessibility.

Firstly, how effectively accessibility features are supported by mobile platforms. Secondly, how the support for accessibility compares between the mobile and traditional desktop environments. Finally, what the accessibility requirements are, within a mobile context, for each web component given their re-aligned rolls (Abou-Zahra et al., 2013). In doing so, Abou-Zahra *et al* suggest potential avenues to explore and request contribution to this research domain.

The Web Accessibility Initiative (WAI) also question the extent to which WCAG 2.0 can address mobile accessibility, even though a mapping has taken place between WCAG 2.0 and Mobile Web Best Practice (MWBP 1.0) (WAI, 2012). Rabin and McCathieNeville state that the MWBP 1.0 provides guidelines for assessing the usability of websites accessed on mobile devices (Rabin and McCathieNeville, 2008).

According to Clegg-Vinell et al a user-centred approach needs to be fully embraced for mobile web accessibility and that guideline for this domain need to incorporate user experience, usability and accessibility with an understanding that these distinct domains overlap and interrelate (Clegg-Vinell et al., 2014).

Figure 1 is adapted from a Venn diagram that indicates the interrelationship between user experience, usability and accessibility as referred to by Wald (2017). For example, if a website requires a user to navigate to a specific link after tabbing through 100 links this would be deemed to be unusable even though every link may be accessible, this would therefore impact the overall user experience.

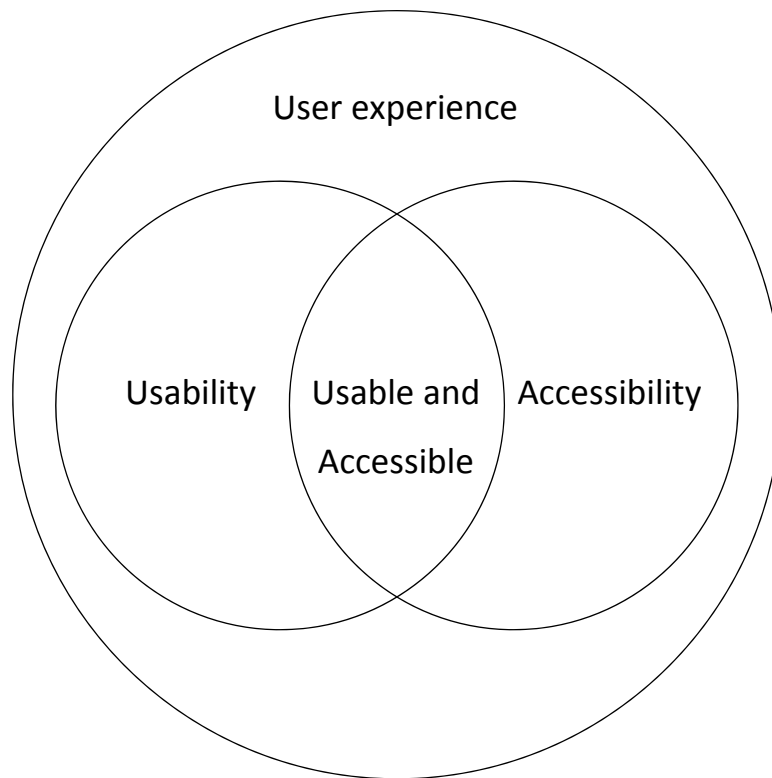


Figure 1: Adapted Venn diagram indicating the interrelationship between user experience, usability and accessibility (Wald, 2017).

2.3 Automatic mobile web accessibility evaluation

According to Vigo et al automatic accessibility evaluation exists that quantitatively assesses mobile web guideline conformance and uses device-tailored tests using a tool supported method and a more generic assessment across all devices against MWBP 1.0 (Vigo et al., 2010). Vigo et al state that the device tailored approach was more reliable than the generic assessment (Vigo et al., 2010). Existing mobile web accessibility evaluation tools rely on the 10 year old MWBP 1.0 guidelines (Kaur and Dani, 2017) and require device characteristics to be taken into consideration. Vigo et al provided a tool for mobile web accessibility evaluation irrespective of the UA, sotware and hardware characteristics (Vigo et al., 2008). According to Vigo et al the tool relied on third party *'device description repositories'* in order to retrieve mobile device features (Vigo et al., 2008).

The mobile first approach (Henry et al., 2014), a paradigm that gave precedence to mobile devices over their desktop counterparts during the development phase, has

acquiesced to coding, such as media queries that recognise the device and enable responsive design to take place. According to Rivoal and Atkins Jr media queries are responsible for enabling responsive web design and development, and enable a device to be interrogated, among other device properties, for screen resolution and size (Rivoal and Atkins Jr, 2015). This interrogation of the device may enable automatic evaluation.

Bandeira et al argue that automatic evaluation is complex and has both advantages and disadvantages. These disadvantages include low accuracy rates, producing multiple false positives, for example warnings of non-existent issues and overlooking real issues (false negatives). Bandeira et al state that certain success criteria also cannot be automatically evaluated (Bandeira et al., 2010). For example, determining minimum contrast levels on a web page or in a PDF document cannot be automated, although automatic processes can detect if settings on a mobile device, in a mobile application or in a mobile browser have high contrast available. Groves provides evidence that programmatically determined web accessibility evaluation indicates that testing by WCAG level' A, AA, AAA for best practice is on average at '18%' and is, therefore, not a substitute for manual testing and that both forms of evaluation need to be undertaken (Groves, 2012).

Vigo and Brajnik argue that the advantages, to automatic evaluation, include a cost effective, easy and fast way to evaluate web pages at scale reliably with results that are reproducible (Vigo and Brajnik, 2011). Bandeira et al also stipulate that there are also a large number of success criteria in WCAG 2.0 that can be automatically evaluated (Bandeira et al., 2010). Manual accessibility testing across five main web browsers can be an arduous undertaking, and with over 200 ereaders (DePriest, 2016), device dependent mobile browsers, mobile web, hybrid, native applications and mainstream electronic formats (eformats) combined, automatic evaluation is essential in this ecosystem.

The W3C state that Web services support this ecosystem and are software systems that are *'designed to support interoperable machine-to-machine interaction over a network'* (W3C, 2004). Web services, according to Giakoumis et al., can also be used by designers and developers to improve their understanding of accessibility constraints for disabled people when exploring user centred design (Giakoumis et al., 2010) and developing accessible applications and services as suggested by Partarakis et al. (2011). This would be

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particularly true for a suite of applications that maximise the accessibility features across all UA's and the mobile web accessibility guidelines embedded in the web services that support them, behaving in a similar way to the aforementioned repository. This does not, however, explain how permissions on mobile devices and within UA's are dealt with. The WAI state that the mobile web browsers are also covered by User Agent Accessibility Guidelines (UAAG 2.0) (WAI, 2016).

Rouse states that mobile browsers are '*[optimised] for [a] small [screen device] and [the] limited resources of a handheld computing device such as a smart phone*' (Rouse, 2018). No published research findings could be found for evaluating mobile browsers for accessibility.

The Information Resources Management Association (IRMA) state that mobile web applications are '*[...] accessed by [a] URL in a web browser (that runs on the mobile device). In most cases, a web app[lication] can be seen as a website that mimics a native app[lication]*' (IRMA, 2017). Accessibility evaluation methodologies exist for mobile web applications but these are limited. Other approaches provide guidance by comparing WCAG 2.0 against other requirements as suggested by specialists to identify shortfalls, particularly in terms of the cognitive domain as referred to by James et al. (2017b).

IRMA maintain that hybrid mobile applications are '*similar to web applications, but the outside is a native shell. Hence, the app[lication] runs within a native app[lication] framework rather than a browser*' (IRMA, 2017). Limited research is available for the accessibility evaluation of hybrid mobile applications, although barriers have been identified for visually impaired users by McKay (2017).

Native applications, as defined by IRMA, '*are designed and coded for a specific [type] of device [and] can usually be found in an app store, such as Google Play, and require the stores approval. They are downloaded from that store and installed on that device[...] and take advantage of the features of the operating system [...]*' (IRMA, 2017). Accessibility and usability evaluations have been undertaken by Billi et al for mobile applications and presented as a unified methodology, using task based evaluation and expert review through heuristic evaluation that enables a newly designed tool to provide applications

suitable for different mobile devices (Billi et al., 2010). This study only involved visually impaired and blind users.

Mobile device accessibility evaluation has also been undertaken but tends to focus on visually impaired users (Leporini et al., 2012), although other research has highlighted and begun to address this deficit (Trewin et al., 2013, Zhong et al., 2015).

The Global Accessibility Reporting Initiative (GARI) provide an online database for accessible mobile devices and applications (GARI, 2018) but do not specify which guidelines or standards are used. Heuristic checklists have also been investigated specifically for smartphone interface design but predominantly focused on visually impaired users. Mi refers to user requirements that were taken from existing guidelines and standards for mobile device accessibility and then used for heuristic evaluation by testing high fidelity prototypes during a usability study. This produced '*six general categories*:

1. *Mechanical controls*;
2. *Display*;
3. *Speech and general operation controls*;
4. *Audio feedback controls*;
5. *Touch operated controls*; and
6. *Others*' (Mi et al., 2014).

Gylling and Herman refer to presentation control (Gylling and Herman, 2014) within a visual context and the PDF/UA standard specifies an audio control category (ISO, 2014). Alongside this are the ETSI EG 203350 Human Factors (HF); guidelines for the design of mobile ICT devices and their related applications for cognitively disabled people (ETSI, 2016), and are in line with the European standard EN 301549 of the EU Directive 2016/2102 (Europa, 2016).

The W3C maintain that WCAG 2.1 refers generally to the functionality of content through the use of a keyboard interface but does not specifically refer to a touch screen keyboard or external keyboard for a mobile device (W3C, 2018). Whereas ETSI refers to functionality specific to mobile software (ETSI, 2016).

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The W3C define functionality as *'processes and outcomes achievable through user action'* (W3C, 2018); whereas a definition by Wood includes device features, in that: *'[f]unctions are the "product's answer to the set of user tasks"; [whereas] features are the "user tools" inherent in the product used to perform the functions'* (Wood, 1995). The term feature can refer to the availability of mobile device, ereader application and mobile browser settings in this context. For example, the functionality of an ereader is to allow the reading of digital content; whereas TTS would be a feature used within the ereader in order to have blocks of text read aloud to the user. These definitions are used throughout this thesis.

Although ETSI offer guidelines that address the accessibility requirements for those with cognitive impairments, there are evaluation methodologies for mobile web accessibility. The International Classification of Functioning (ICF) have been integrated into the Harmonized Accessible Methodology (HAM) and provide interaction constraints for disability type profiles that can be used to evaluate mobile web accessibility. For example, these profiles include user groups for cognitive, hearing, visual, communication received and producing, and upper limb impairments (Chalkia et al., 2009). The RIAM Framework, as referred to by Yesilada, is not dissimilar and captures the requirements of Human-Web interaction for a wide range of impairments such as motor impairments, visual impairments and cognitive impairments (Yesilada et al., 2009).

These evaluation methodologies generally support the accessibility requirements for print impairments, and are particularly relevant to evaluation methodologies relating to HE electronic texts for those with print impairments. Hegarty and Wusteman suggest that mobile accessibility will be required as a potential selection criteria by library staff (Hegarty and Wusteman, 2011).

Brajnik refers to manual accessibility Conformance Review (CR), also referred to as Standards Review, that requires an auditor to determine if accessibility criteria are met when comparing either a Web 2.0 service or application and a severity weighting is awarded (Brajnik, 2008). For example a severity weighting of 1, 2 or 3. '1' being inaccessible and '3' being accessible with an intermediary stage being partially accessible.

There is, however, a caveat in that certain success criteria may not be applicable and so would require a scoring method to distinguish this, perhaps indicated by a '0' or '-'.

2.3.1 Barrier walkthrough method, automatic evaluation and human evaluation

Brajnik introduces a heuristic walkthrough method based on accessibility barriers and refers to this as a Barrier Walkthrough (BW) method. According to Brajnik accessibility barriers are defined as any situation where, despite the use of AT, achieving a specific goal is problematic (Brajnik, 2006). Sears argues that heuristic walkthrough is not only a task-orientated evaluation method it can be applied effectively and learned easily. Sears also stipulates that it has greater validity than heuristic evaluations (Sears, 1997). Nielsen and Molich state that heuristic evaluations typically require an evaluator to comment on an interface design in accordance with relevant guideline rules (Nielsen and Molich, 1990) or criteria.

Yesilada et al state that it is straightforward to extend the BW method by introducing new barrier types for different user groups and is essential for analysis. Yesilada et al mix collected barrier types experienced by mobile web users with those experienced by visually impaired, including blindness, and motor impaired users (Yesilada et al., 2011). Brajnik emphasises user characteristics that are separated into categories relating to low vision (including blindness), cognitive, motor and hearing impairments (Brajnik, 2006). According to Brajnik it is relatively straightforward to claim conformance when generating a BW report, particularly as the accessibility barriers referred to relate to established guidelines (Brajnik, 2007).

Brajnik states that the BW method has greater validity, and is more useful, than conformance testing because a considerably higher proportion of critical true accessibility barriers are exposed (Brajnik, 2007). In order to apply the method, Brajnik suggests that a variety of separate scenarios need to be ascertained based on user tasks that are category specific, user characteristics, goals, and settings (Brajnik, 2006). Brajnik does not explicitly clarify what the settings are, relating perhaps to environmental or situational factors or the settings available when using AT. Brajnik does, however, maintain that the tasks and user goals are defined only in terms of the website being tested (Brajnik, 2006).

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Brajnik provides an example that user categories would need to be analysed against potential information requirements for specific sets of website pages (Brajnik, 2006). In terms of evaluating web applications the user tasks and goals typically provided in documented use cases would need to be analysed against user categories to determine the relevant scenarios as referred to by Brajnik (2006).

According to Brajnik, in order to undertake this analysis the BW method requires a 1-2-3 scale for grading the severity of the barrier encountered by the user and is based on impact and frequency (Brajnik, 2007). This impact relates to the extent that the user goal is not achieved within the relevant scenario, and the frequency is determined by the number of times a specific barrier occurs when a user attempts to achieve a specific goal. Brajnik also emphasises that by coupling the use of '*accessibility evaluation tools*' and '*human judging*' with the BW method that useful results can be obtained when ranking a set of web pages and comparing more than one website (Brajnik, 2007).

Automatic evaluation tends to be undertaken using accessibility evaluation tools, such as the web accessibility evaluation tool developed by Web Aim, referred to as WAVE.

According to Brajnik, such evaluation tools enable '*checkpoint violations*' to be collected for a website that then undergo a mapping with specified barriers encountered during the walkthrough (Brajnik, 2007). Sampling a subset of these violations enables a human judge to assess the severity of the encountered barrier against the violated checkpoint. In doing so Brajnik states that justifiable conclusions can be made about the error rate for a specific barrier based on quantitative and statistical analysis (Brajnik, 2007). This demonstrates how the BW method is more than an evaluation method but also a tool that supports automatic evaluation alongside human evaluation.

Human evaluations (human judging) are not only possible using the BW method, as previously mentioned, but also enable the evaluator to comprehend what the impact is of the barrier in relation to the user goals and the frequency of the barrier occurrence as specified by Brajnik (2006). This is particularly useful where there maybe a variation in the expertise of stakeholders or a difference in the domains covered by stakeholders.

Bandeira et al suggest that these stakeholders may include '*non-technical or expert evaluators, designers and developers*' and can be deliberately targeted (Bandeira et al.,

2010). In addition to this Bandeira et al state that best practice, guideline application and development phases can also be targeted (Bandeira et al., 2010). In this thesis the stakeholders deliberately targeted were academic and student users, Higher Education Institute (HEI) librarians, academic publishers and academic aggregators.

2.4 Higher Education electronic texts for print impairments

Pre-Web, Carey and the Electronic Text Consortium (ETC) provided a study that assessed the applications within HE for etexts (Carey, 1984). Dozier investigated the dissemination of etexts by faculty and amongst university students and anticipated the use of etexts in HE with the provision of electronic bookstores and electronic libraries (Dozier, 1985). Although etexts clearly have a place within HE, their use is not restricted solely to the HE environment. Digital accessibility is also a requirement within public libraries and mainstream ebookstores (Whitehouse, 2011), such as Amazon.com as suggested by (Bläsi and Rothlauf, 2013).

Whitney and Castell maintain that Trade Ebooks, are retail ebooks aimed at individual consumers and that libraries were unable to add them to their collections (Whitney and Castell, 2017). According to Whitehouse this required the legal frameworks to be investigated that caused this issue and for remedial action to be taken that removed this barrier to library access (Whitehouse, 2011). Navarro-Molina et al maintain that the accessibility of scientific ejournals is limited (Navarro-Molina et al., 2018).

2.4.1 Differences between etext, ebook and etextbook

Baron refers to the term 'eText', with a lower case initial letter and uppercase second letter, and states that it is used predominantly within the educational domain to refer to digital textbooks (Baron, 2014). Baron queries the ambiguity of the term and suggests that an electronic text would present itself as any form of digital content that can be displayed on an electronic screen. Baron also defines an eBook as a book produced digitally and suggests that 'eReading' can take place on any given electronic device such as a desktop computer, laptop, dedicated eReader, tablet or a smartphone. Luceno defines an ereader as a device predominantly required to read digital publications (Luceno, 2014).

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In light of the term 'eText' as described by Baron, nine additional non-hyphenated terms become available, namely:

1. eBook;
2. eBookstore
3. eCatalogue
4. ePub;
5. ePublication;
6. eJournal
7. eReader;
8. eTextbook
9. eContent

Wexelbaum *et al*, also distinguish between an etext (electronic text) and an ebook, whereby an ebook may use multimedia features, such as hyperlinks and audio; whereas an etext does not and is solely distributed in the ASCII (plain text) format (Wexelbaum *et al.*, 2011). Wexelbaum *et al*, also provide a definition for an etext and state that it '*is a digital version of a published work, such as a book*' and is the reason why the terms etext and ebook can be used interchangeably. Wexelbaum *et al*, clarify, however, that an ebook is distinct from an etext in that an ebook requires a proprietary platform for it to be read using a specific electronic device or application (Wexelbaum *et al.*, 2011). For example, opening a PDF in Adobe Acrobat Reader.

There are examples of the term 'eText' currently in use by Baron (2014) and Knight *et al.* (2017). No explanation as to either the capitalisation or the use of lower case prefixes in this context could be found in the published research findings and would suggest that these are arbitrarily assigned. So for example, Wexelbaum *et al* favour 'EBook', using an initial uppercase 'E' followed by an uppercase 'B', regardless of the position in the sentence. Other spellings of the same word were presented, so for example '[...] *ebook, eBook, e-book, or e-Book*' (Wexelbaum *et al.*, 2011). Hyphenation of e-text (Wexelbaum *et al.*, 2011) is also in use. Therefore, although 'eText' is identified by Baron as a term more commonly used in the educational domain, this needs to be metred by the distinction made by Wexelbaum *et al*. In so doing the term 'eTextbook' would need to be ultimately considered; but since no multimedia is being evaluated in this research only

the term 'eText' will be used throughout this thesis. In doing so, however, its use needs to be rationalised. If the term is used at the start of a sentence it will take the form 'Etext'; whereas if it is used mid sentence it will be in the form 'etext'. The same logic applies to the eight remaining terms previously mentioned, as and when they are required in this thesis.

2.4.2 Adoption of mobile devices, ereaders and etexts within the Higher Education ecosystem

Murray *et al* highlight the slow adoption of HE etexts and state that with the rapid evolution of the textbook market the etext is a strong contender (Murray and Perez, 2011). According to Vasileiou *et al.* the Portable Document Format (PDF) has been found to be the preferred format for librarians because of its ease of use, search capabilities and text linking (Vasileiou *et al.*, 2012a).

Kasdorf states that the EPUB2 format should be discontinued as the majority of reading systems and vendors are able to support the EPUB3 format (Kasdorf, 2017). The International Digital Publishing Forum (IDPF) also refers to '*reading systems*' (Luceno, 2014) rather than ereaders. Reading systems, as described by Durrell, have been used to describe different approaches or methods to teach reading, an example of which was the Basal-reading system (Durrell, 1956). Luceno also considers mainstream reading systems but does not refer to the '*symbiotic relationship*' (Draffan *et al.*, 2014) between digital content and the device. The IDPF also tends to capitalise 'EPUB'; in contrast to the 'ePub' previously mentioned (IDPF, 2017) and it is for this reason that when referring to the format the capitalised term EPUB, with its corresponding version type, will be used throughout this thesis. For example, EPUB2 or EPUB3.

Bläsi and Rothlauf, advocate the adoption of the EPUB format over other proprietary formats – such as PDF or AZW (Amazon format), because there is no functional or technical reason that exists to prevent the EPUB3 standard from becoming the open interoperable ebook format standard (Bläsi and Rothlauf, 2013). Bläsi and Rothlauf, argue that the corralling of ebook ecosystems, through the use of Digital Rights Management (DRM), by mainstream vendors impedes complete interoperability. Ward *et al* echo this

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premise in part and state that a consistent user experience is hindered by issues with different access restrictions and copyright issues (Ward et al., 2015).

Bläsi and Rothlauf suggest that this can in part be resolved by these vendors, but only if there is a willingness to respectively alter reader applications in store, across this ecosystem, therefore reducing barriers imposed by DRM. Bläsi and Rothlauf also stipulate that unilateral agreements between vendors would provide interoperable DRM solutions. Russell suggests that contractual expectations for accessibility may offer a way forward in this scenario (Russell, 2017).

Luceno, places the responsibility of ebook accessibility within the remit of the publisher (Luceno, 2014). In a personal correspondence, McNaught remarks on why publishers are not pro-active in terms of ensuring embedded accessibility. McNaught prefaces this by stating that larger publishing houses are more likely to be engaged with and proactively supporting the accessibility of digital content. McNaught suggests that publishers who are not pro-actively ensuring embedded accessibility are not '*hassled*' enough, and from a publishers perspective there is limited commercial demand. This emphasises the disconnect between the request rates publishers are receiving, and the request rates sent from HEI libraries for the provision of accessible library content. In doing so this demonstrates that publishers are unaware that they are missing 25% of their market share. McNaught suggests that the reason for this is that users are unaware of '*what to ask for*' and that HEI libraries have legacy workflows that are in the process of catching up with technology (McNaught, 2016b).

2.4.3 Mobile device usage in Higher Education

The widespread use of mobile devices in HE (Delcker J. et al., 2018), and the accessibility of web based institute portals (Whitehouse, 2011) need further investigation in order that disabled people can access these platforms. Cheung stipulates that notebook computers are typically used for assignment work; whereas tablet devices tend to be used for ereading and connecting to learning portals while mobile phones are used for social media (Cheung, 2015).

The procurement of institute devices, a model that is identified in the published research findings as being unsustainable; but intended to alleviate the digital divide (JISC, 2011), is contrasted with the increase of wireless connectivity in mobile friendly library Information Technology (IT) infrastructures, favouring the use of Bring Your Own Device (BYOD) policies as stipulated by Draffan et al. (2014). In doing so, users would be more familiar with their own devices and would not be required to upskill when using an institute device. However, this is with the understanding that there is a contrast between Disabled Students' Allowance (DSA) funded devices and those generally purchased by the institute. Draffan states that the devices provided to individuals under the DSA are not mandated but advised to suit the accessibility requirements of the student (Draffan, 2014). In order to alleviate upskilling, standardising the accessibility settings across devices would be a useful baseline. It is unlikely, however, that mobile device manufacturers would adhere to this form of standardisation.

Deeprise provides a report published in the UK by iSolutions at the University of Southampton that infers device usage based on the number of times users accessed Blackboard, an institute Virtual Learning Environment (VLE) since July 2013 to April 2016 (Deeprise, 2016). Deeprise, states that the figures were obtained using Google Analytics (GA), and that this form of analytics has limitations, in that certain users were excluded from the report if they blocked GA or were using a service that did the same. The figures provided by Deeprise are also from a single HEI and cannot be generalised to all HEI's.

Deeprise provides a summary, stating that the most commonly used desktop operating system used to access Blackboard was Windows '(67.28%)'; whereas the iPhone accounted for '(51%)' of the mobile devices accessing Blackboard. This suggests that the majority of desktop computers use Microsoft Windows; whereas the predominant mobile platform was the iPhone. The figures obtained by Deeprise echo the data held by Statista that up until September 2015 the iOS operating system was more predominant, whereas in December 2015 the Android OS regained dominance (Statista, 2019). The International Data Corporation (IDC) provides data relating to the global Smartphone OS Market Share for the second quarter of 2015. The Android and then iOS devices were the front runners; whereas the Windows and Blackberry devices follow behind by a significant margin with Android maintaining smartphone market dominance (IDC, 2015).

2.4.4 Stakeholders in the HEI library domain

Whitehouse investigated the relationship between eight stakeholders within the academic and non-academic domains, indicated in Table 1, that are relevant to reading etexts in libraries (Whitehouse, 2011). Whitehouse does stipulate that although online bookshops and libraries were investigated, specific attention was given to the trade publishing sectors and Higher Education (Whitehouse, 2011).

Table 1: Stakeholders as investigated by Whitehouse (2011) in the academic and non-academic library domains.

Academic domain	Non-academic domain
1. Academic or Student;	5. General public;
2. Academic librarians in university libraries;	6. Librarians in public libraries;
3. Academic publishers;	7. Non-academic publishers;
4. Academic aggregators;	8. Non-academic aggregators.

Academics and students are both referred to by Whitehouse who involved a blind academic in testing a bookshop website for accessibility, and also refers directly to a student making use of an institutional portal (Whitehouse, 2011). McNaught et al emphasise that for an academic user the process of navigating the institute's platform and authentication through to accessing etext was multi layered (McNaught et al., 2010). McNaught et al stipulate that a student user was required to '*negotiate up to eight separate systems*' (McNaught et al., 2010). Since this thesis focuses on HE etexts, the four stakeholders in the academic domain, referred to in Table 1, were selected for this research.

Academic and university librarians are referred to interchangeably by Whitehouse alongside the involvement of disability support workers (Whitehouse, 2011). The librarian and/or disability support worker may need to intervene on behalf of the academic user if an accessibility barrier is encountered. For example, Whitehouse describes a scenario where a visually impaired user required access to an older accessible version of an institute's website (Whitehouse, 2011). Whitehouse then describes how the institute

library takes remedial action by arranging for the institute portal to recognise the students AT and to open the older accessible version of the website (Whitehouse, 2011). Whitehouse also suggests that this would be possible even though the librarian and/or disability support worker may not be aware of the technicalities involved (Whitehouse, 2011). According to Whitehouse accessibility rates within HE are greater because the onus has been placed on universities to adhere to legal requirements combined with the efforts of specific academic publishers and third party organisations (Whitehouse, 2011).

Academic publishers, as referred to by Whitehouse (2011), are discussed within the context of teasing out the responsibilities for the accessibility of each stakeholder, legal or otherwise. The Special Education and Additional Needs Act of 2001 placed the onus of accessible literature on the HEI (Kingdom, 2001). Whitehouse questioned the legal obligations of the academic publisher with the intention of increasing the publishers responsibility for accessibility (Whitehouse, 2011). Luceno suggests too that ebook accessibility is dependent on publishers and that even with the accessibility features available within the current EPUB3 format it is still possible to produce an inaccessible publication (Luceno, 2014).

According to Whitehouse, at the time of writing, Academic Aggregators are beginning to take accessibility seriously (Whitehouse, 2011). According to Russell, aggregators provide licensed full-text content and work in tandem with publishers as content providers for libraries. Russell maintains the provision to libraries takes the form of hosting collections made available either through subscription or as pay-per-view services. Although these aggregators are not only becoming the primary hosts for licensed full text content there is also an increasing tendency for aggregators to include web discovery service provision. In doing so this enables users to transition seamlessly between indexed content on library platforms and hosted content provided by these types of aggregators (Russell, 2018).

Whitehouse also draws attention to the issue of addressing potential solutions in isolation for the accessibility of ebook platforms produced by aggregators and states that publishers also have to be involved in the process (Whitehouse, 2011). This is a valid argument since academic publishers are responsible for producing both PDF and EPUB

digital content, it seems reasonable to suggest that the responsibility for accessibility falls within the publishers remit.

2.4.5 Print impairment

Although no official academic definition could be found in the literature for the term print impairment, there are, however, references made to it. The Publishers Association, use the term in guidelines that refer to copyright exceptions for the print impaired in conjunction with the Marrakesh Treaty (PA, 2015). Other organisations refer to print impairment, namely the UK Association for Accessible Formats (UKAAF) (UKAAF, 2017) and Dedicon (Consortium, 2017) suggesting a possible European usage.

Impairment, as opposed to disability, has been defined by Harris (1971) as: *'lacking part or all of a limb, or having a defective limb, organ or mechanism of the body'* seating it within the physiological domain. Schroedel *et al*, however, develop this further and include the cognitive domain by suggesting that: *'impairment refers to a physical, mental or sensory loss resulting from a bodily disorder or pathology'* (Schroedel, 1978). Three years prior to this, the Union of the Physically Impaired against Segregation (UPIAS) strongly stated, that individuals with physical impairments are disabled by society because of barriers inherent in the physical world (Priestley *et al.*, 1997). This forms the basis for the Social Model of Disability (SMD) where for example, providing a ramp as opposed to steps for a wheelchair user removes the disabling barrier. The philosophical perspective adopted for this research was the SMD as opposed to a positivist approach, otherwise known as the medical model.

The SMD echoes the premise of Universal Design, as referred to by Vanderheiden and Tobias, whereby it is the

'process of creating (devices, environments, systems and processes) which are useable by people with the widest possible range of abilities, operating within the widest possible range of situations (environments, conditions, and circumstances)' (Vanderheiden and Tobias, 1998).

For example, a ramp in place of steps not only enables a wheelchair user to enter a building unhindered but that this would also allow a pushchair to do the same (Goldsmith, 1997, Mace et al., 1997).

In the UK, the Equality Act 2010 defines disability as a person with *'[...] a physical or mental impairment that has a 'substantial' and 'long-term' negative effect on [the individuals] ability to do normal daily activities'* (Crown, 2010).

The literature also uses two distinct phrases, namely: 'people with disabilities' and 'disabled people'. Since disability is a by-product of the barriers prevalent in society, the phrase 'people with disabilities' could be seen as a misnomer. In this thesis both phrases are used with an understanding that in certain countries, such as the US, people with disabilities (PWD) is the preferred phrase; whereas in the UK the phrase disabled people is more prevalent.

Print disability, has been defined by Kerscher as *'[a] person who cannot effectively read print because of a visual, physical, perceptual, developmental, cognitive, or learning disability'* (Kerscher, 2015). The term print disabled, however, does not seem to adequately describe the problems experienced by individuals with dyslexia or other issues with reading and writing who, potentially do not have difficulties with visual acuity. Therefore, the term print impairment will be used throughout this thesis. Print impairments also include those with visual processing difficulties, for example visual stress as referred to by Web2Access (2018).

Based on three main disability types the following key accessibility requirements were identified within the HE etext mobile web domain for print impairments.

1. *Visual impairments (including blindness):*

Visually impaired or blind academics and students need to be able to navigate an institute portal from logging in through to downloading and reading an electronic format. This is achieved through the use of a screen reader for blind users or high contrast mode, zoom/magnify and reflow for visually impaired users. According to Whitehouse the use of AT like this also requires the means to manage issues such as timeout during the log in process and DRM (Whitehouse, 2011). Bläsi and

Rothlauf argue that DRM prohibits the exporting and importing of formats between third party ebook ecosystems (Bläsi and Rothlauf, 2013). For example, within these ecosystems Apple and Amazon provide incompatible ebook formats that are device specific, such as Amazons ‘.AZW’ format that cannot be read by the Apples iOS iBooks reader. Bläsi and Rothlauf state that this is further complicated by Apple and Amazon who ring fence their ecosystems with software that restricts access using encryption, namely DRM measures (Bläsi and Rothlauf, 2013).

2. *Dyslexia:*

Since dyslexia is a disability that affects reading (Rello, 2014), academics or students require the means to be able to simplify and to customise text (Henry, 2012) in conjunction with the ereader and institute portal interface. In particular an optimal font size of up to 18pt (Rello, 2014) has been specified alongside the use of Text to Speech (TTS) and options to alter text and background colour by Rello and Barbosa (2013). Although 18pt maybe problematic on a mobile device, especially a small screen device such as a smartphone. Alongside the settings being made intuitive (Blackler et al., 2010) the functionality of an ereading user interface, as stipulated by Brajnik and Harper, is limited (Brajnik and Harper, 2016). Although this seems counter intuitive, a simplified user interface as suggested by Newell would also be an accessibility requirement particularly for those who experience the onset of age related impairments (Newell, 2011). This would particularly be the case for an ereader.

3. *Physical difficulties (impacting dexterity and fine motor skills):*

The main accessibility requirements for users with physical difficulties of handheld devices are target size (Trewin et al., 2013) and the means to control steady tapping (Zhong et al., 2015). For example, it has been recommended by Guerreiro et al. that 12mm will enable motor impaired users to acquire targets based on touching specific parts of the devices screen (Guerreiro et al., 2010). For the purposes of this thesis, navigation will be defined as requiring touch, particularly when input impairments occur as stated by Brown et al. (2010).

2.4.6 The prevalence of print impairment in UK Higher Education

Table 2 provides a summary of the data sets obtained from the UK Higher Education Statistics Agency (HESA) from 2014 to 2018 respectively.

Table 2: Summary of HESA data sets from 2014-2018 for the prevalence of print impairment in UK HE.

HESA data set: year	Total number of students	% Print Impairments
2014/15	2,266,075	5.38%
2015/16	2,280,830	5.48%
2016/17	2,317,880	5.52%
2017/18	2,343,095	5.48%

In the UK the Higher Education Statistics Agency (HESA) dataset for 2014/15 indicated *'the number of [print impaired] students by disability and Disabled Students' Allowance [DSA] marker'* (HESA, 2017a). HESA state that the figures include both full and part time students. The dataset for *'HE students by level of study and mode of study 2014/15'*, state that the total number of HE students, both full and part time was 2,266,075 (HESA, 2017a), and of this total 5.38% have disabilities relating to print impairments. This was based on the total figure of 121,865 disabled students indicated in (Appendix B1).

The same applies when examining the 2015/16 dataset (HESA, 2017b). The total number of HE students, both full and part time was 2,280,830, and of this total 5.48% have disabilities relating to print impairments. This was based on the total figure of 124,930 disabled students indicated in (Appendix B2). When examining the 2016/17 dataset (HESA, 2017c), the total number of HE students, both full and part time was 2,317,880, and of this total 5.52% have disabilities relating to print impairments. This was based on the total figure of 127,990 disabled students indicated in (Appendix B3). The 2017/18 dataset (HESA, 2019) indicates that the total number of HE students, both full and part time was 2,343,095, and of this total 5.48% have disabilities relating to print impairments. This was based on the total figure of 128,315 disabled students indicated in (Appendix B4).

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Based on the data supplied by HESA the proportion of students with Specific Learning Disabilities (SpLD's) is significantly larger than students who are blind or have a severe visual impairment or who have physical impairments. It is likely these figures will be higher because of undisclosed disabilities. According to the British Dyslexia Association (BDA) an SpLD is an umbrella term that includes dyslexia (BDA, 2016). HESA also stipulate that a suppression and rounding strategy is used in their datasets. This was implemented so as to be in compliance with the Data Protection Act 1998.

Policy decisions made by the Department of Business Innovation & Skills (BIS) (Underwood, 2014) has meant that key changes have been made to the DSA. According to JISC the Public Sector Equality Duty both further and higher education institutes must proactively anticipate the requirements of disabled people requiring access to and participation in activities for tertiary education (JISC, 2013a). Draffan concurs by stating that institutes have a responsibility to provide the type of assistance specified in the Equality Act 2010 instead of being reliant on DSA funding to support the cost of AT's and accessible resources (Draffan, 2014).

Draffan maintains that because of financial reductions the AT landscape is altering, impacting not only the users, practitioners and organisations across the sector but also the level of expertise available supporting training for the many built-in and freely available technologies. Draffan also argues that the DSA may not make full financial contributions towards technology device options for those claiming DSA support, placing the onus on institutes to improve alternative format provision. In doing so, institutes may seek alternatives that would reduce educational expenditure by increasing access through Open Educational Resources, but there are no guarantees that these materials will be accessible in terms of ease of use and access to AT's such as screen reading or text to speech, despite the guidance that might be offered on the subject (Draffan, 2014). According to the UK Association for Accessible Formats (UKAAF), since VAT has been removed from mobile devices with specialist software, it is likely assessors may attempt to get mobile technologies for disabled students with AT on board (UKAAF, 2017).

Yesilada et al highlight the similarities between disabled and mobile web users, whereby the barriers encountered by mobile web users are akin to those of motor impaired and

visually impaired users and refer to these as situationally induced impairments (Yesilada et al., 2011). For example, a mobile web user is situationally impaired when reading text on a small screen device and is required to scroll horizontally because of text size, likewise that a visually impaired user might be required to use magnification (zoom) for the same purpose on a large screen and also be required to scroll horizontally.

2.4.7 Situationally induced impairments and Disabilities (SIID)

Sears introduces the term Situationally-Induced Impairments and Disabilities (SIID) and emphasises their dynamic and temporary nature within the context of health related disabilities (Sears et al., 2003). For example, Sears suggests that due to physical impairments, such as the loss of a limb and depending on the availability of input technologies, computer-orientated disabilities are caused. Similarly Sears refers to hands-busy situations that can have the same outcome. Within this context Sears highlights how health related conditions, such as mobility, requiring speech based interactions can be impeded within a noisy environment when using computing devices. In a further example, Sears demonstrates how mobility might also be temporary in terms of the activities required by a paramedic travelling in an emergency vehicle. The movement of the ambulance combined with the demands of delivering necessary health care to a patient on board would impede a paramedic's ability when interacting with a physical input device. Speech-based interactions would also be hindered because of external road noise and the vehicles siren. Sears also refers to other salient factors that impact a user's ability when interacting with computing technologies, for example, the demands made on a user's attention, stress, lighting and temperature (Sears et al., 2003).

Sarsenbayeva et al, more recently, refer to seven situational impairment categories based on the published research findings:

1. *'Ambient temperature* [such as operating a device in a cold environment];
2. *Mobile state of the user*;
3. *Encumbrance*, [such as carrying an object];
4. *Ambient light*;
5. *Ambient noise*;

6. *Emotional state of the user (mood)*; and
7. *Stress*' (Sarsenbayeva et al., 2017).

Sarsenbayeva et al not only suggest that situational impairments need to be detected with solutions that mitigate the impact on mobile interaction, but that it is essential to exceed this by accommodating users accordingly (Sarsenbayeva et al., 2017). Since there are similarities between disabled and mobile web users, Yesilada et al state that aggregating the evaluation results for disabled user groups has been used to provide an approximation for the evaluation results of mobile web users (Yesilada et al., 2011). According to Yesilada evaluation methodologies such as this are attempting to reduce the number of conformance criteria that pertain to MWBP (Yesilada et al., 2011).

2.4.8 Evaluation methodologies

McNaught and Alexander provide an early institute library procurement checklist (McNaught and Alexander, 2014). Figure 2 indicates an adapted version of the original that serves as a precursor to an instrument checklist.

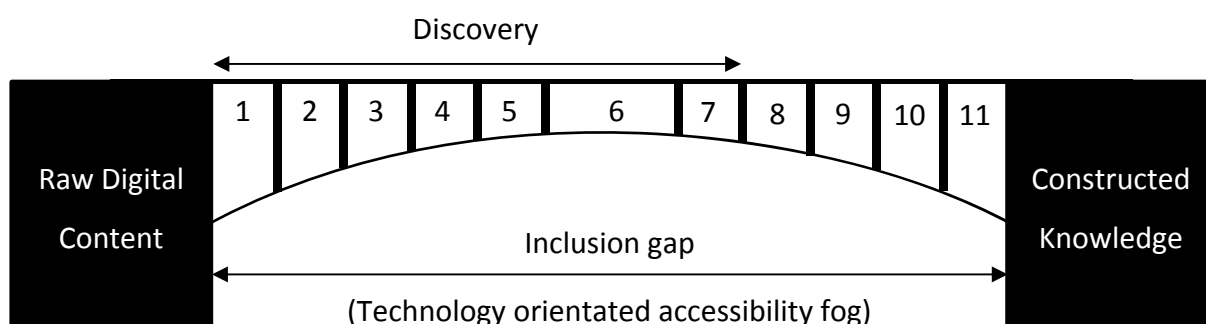
Initial instrument checklist:

1. Does the device or user agent provide a maximum font size of 18pt? (Rello, 2014)
2. Does the device or user agent provide a notification about TTS once the maximum font size is reached?
3. Does text reflow when type size is enlarged?
4. Can a user change background/foreground colours or contrasts?
5. Does the device or UA provide connectivity for a Bluetooth keyboard?
6. Does the device or UA provide connectivity for a Braille display? (Whitehouse, 2011)
7. Does the device provide a Contextual Menu or Rotor that allows meaningful navigation through the semantic structure of an etext viewed in the browser?
8. Can text be selected and read by text-to-speech tools?
9. Can the device detect alt-text for images or equations so the user can be notified that the image or equation exists in the etext?

Figure 2: Initial Instrument checklist, adapted from McNaught and Alexander, 2014.

In a separate study, McNaught *et al* provide the eBook Access Bridge Model that identifies an inclusion gap between '*raw digital content*' and '*constructed knowledge*' on an institutional learning platform (McNaught et al., 2010). McNaught *et al* state that the accessibility of etexts for the average institutional user is unexpectedly multi-staged, and

that he or she is required to negotiate different institutional systems to move from the raw digital content to constructed knowledge. McNaught *et al* identify a technology orientated ‘*accessibility fog*’. This is where the institutional user, who may have personal accessibility requirements, is dependent on each stage in the process being accessible to their AT – emphasising potential issues with compatibility and interoperability. The user may also be uncertain as to how to overcome barriers if they occur. Figure 3 is an adaptation of this model. The sequence of the stages 1-11 are not set: so for example, a search for a title – stage 6 – may take place on Google or Project Gutenberg prior to accessing the institute platform. McNaught *et al* maintain that the tasks undertaken by participants in their study were user-orientated; whereas the accessibility fog was technology orientated (McNaught *et al.*, 2010).



User Tasks

1 Navigate to institute platform	7 Download the econtent Format
2 Authenticate & login to institute	8 Navigate within the title using the ereader as an application, browser or webview.
3 Navigate to ecatalogue	
4 Authenticate & login to ecatalogue.	9 Navigate within the econtent
5 User Agent (UA) to use library metadata index	10 Access the text (directly or indirectly)
6 Search for title (search box)	11 Export data & quotes to assignment

Figure 3: Ebook Access Bridge Model, adapted from McNaught *et al* 2010.

According to Dobson and McNaught, in the UK, a crowd sourced ebook accessibility audit developed by JISC and partnering HEI’s addresses the issue of technical language between HEI libraries and academic publishers. It also enables ebook providers and librarians to be able to use the audit as a framework to effect change and discuss best practices in

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accessibility (Dobson and McNaught, 2017). This crowd sourced audit is the only known manual approach in the UK. Additional research by James et al emphasised the benefits between accessibility standards implemented by developers and those that are crowdsourced non-expert accessibility evaluations undertaken by non-experts (James et al., 2017a).

According to Mune and Agee accessibility evaluations have been undertaken for RDT interfaces, identifying shortfalls where academic publisher and academic aggregator platforms are lacking in basic accessibility features long since provided for by commercial ebook providers (Mune and Agee, 2016). Further accessibility evaluations by Beyene and Ferati also indicate that these interfaces need to be simplified and designed to meet the needs of disabled people alongside adaptations to these interfaces for this target group (Beyene and Ferati, 2017).

Benyon and Murray state that adaptable systems allow a user to make manual changes to specific features; whereas an adaptive system automatically makes changes as it monitors the users' interaction with the system during run time (Benyon and Murray, 1993).

However, Van Velsen et al combine the two terms and refer to this as personalisation (Van Velsen et al., 2008). In this thesis the two terms adaptive and adaptable were not merged because two other terms, namely customisation and personalisation are used in more current published research findings that of Schade (2016).

Schade states that customisation refers to the ability of a user to be able to make manual changes to the features available on an interface; whereas personalisation is where automatic changes are made by the system (Schade, 2016). Adaptive interfaces offer benefits to disabled people, particularly in terms of meeting their accessibility requirements, such as simplifying the functionality of an interface as suggested by Newell (2011).

In addition to this, Wechsung argues that redundancy on a user interface is necessary as this provides multiple channels by splitting information and thereby reducing cognitive load for the user (Wechsung, 2014). This has similarities to WCAG 2.0 SC 2.4.5 Multiple Ways – Level AA. According to Vanderheiden et al the library GPII system (LGS), offers personalisation, through personal preferences and needs to the library domain with

reference to cross platform support for all major operating systems, including Android, iOS, Windows, and browsers (Vanderheiden et al., 2014). It does not, however, explicitly refer to how accessibility metadata in the mobile web domain can be used. Another potential tool is ATbar, a cross browser toolbar offering AT (UoS, 2011) that that could be used in the mobile web context.

In order for automatic changes to occur this requires machine readable code referred to as metadata. Metadata undergirds the mobile web accessibility HE ecosystem (Beyene, 2017), from mobile devices through to institute portals and the formats downloaded by academics or students using RDT's.

Discovery refers to academics or students searching for, finding and downloading online digital academic texts, and is integral to what institute libraries refer to as a Federated Search Tool within the institutional domain (Yang and Wagner, 2010) or Resource Discovery Tool (RDT) (Beyene, 2016). According to Yang and Wagner in the public domain it is referred to as the '*Discovery Layer*' (Yang and Wagner, 2010).

According to Beyene accessibility metadata, for example, enables accessible resources to be exposed to search engines and augments library RDTs and benefits disabled people (Beyene, 2017). It also enables users to rapidly discover materials that meet their accessibility requirements (Vasileiou et al., 2012b). Beyene and Godwin state that evaluations have been undertaken for accessibility metadata through the use of RDTs and have revealed that the decisions made about metadata by HEI libraries must be informed by the users accessibility requirements and how this can be exploited to improve the user experience and accessibility of RDTs (Beyene and Godwin, 2018). This research focuses solely on search metadata and does not, however, cover the extent of accessibility metadata and its availability across the entire HE etext ecosystem for print impairments. Accessibility metadata in this context is the master key component with its ability to unlock hidden digital information and to make it humanly readable.

Etext formats, such as the Portable Document Format (PDF) and the EPUB version 3 (EPUB3), also make provision for accessibility metadata. Drummer states that the Universal Accessibility PDF standard, PDF/UA (ISO 14289-1), based on a mapping with WCAG 2.0 Success Criteria, enables for example, the display and reflow of an electronic

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document on a small screen device and is based on the same underlying technology that allows a screen reader to read a PDF out aloud (Drummer, 2012). This does, however, rely heavily on the correct coding of the PDF to allow this feature to be made available in an ereader, such as Adobe Acrobat. If, however, a PDF does not comply with PDF/UA, the text in a PDF will not reflow. Evaluation tools also exist for PDFs. The PAC3 and PAVE 2.0 tools are third party software that enable the accessibility evaluation of PDFs. These tools do have their limitations for complex PDFs and require subscription when used commercially.

The IDPF EPUB3 standard details the provision for accessibility metadata under the ONIX for Books Code list 196 (IDPF, 2017). For example, according to Garrish this code list provides metadata that will enable a user within an application to expose in what way the EPUB3 meets their accessibility requirements (Garrish, 2012). The IDPF also maintain that crowdsourced accessibility evaluations have also been undertaken for the EPUB3 format (IDPF, 2013). This indicates the potential benefits for accessibility but as Alexander, formerly of SAGE publishing states, is reliant upon adoption from academic publishers (Alexander, 2017).

The DAISY Consortium, via the Inclusive Publishing website, have also recently stated the release of ACE, the accessibility evaluation tool for automatically evaluating EPUB3 publications providing clarity to the publishing sector regarding accessibility (IP, 2017). In addition to this DAISY state that the EPUB3 format has fully embraced the accessibility features referred to by the DAISY standard (DAISY, 2018). Although both PDF and EPUB3 accessibility evaluation tools exist they have not as yet been incorporated into a mobile web accessibility framework, such as a web service (Arrue et al., 2007), used in the HEI library mobile web ecosystem for those with print impairments.

Maatta and Laurie state that minimal research has been undertaken to measure the functionality and accessibility for those with print impairments in academic and library environments using dedicated hardware based ereaders such as the Kindle platforms (Maatta and Laurie, 2014). Although other research by (Rello and Baeza-Yates has shown that UA based ereaders can be developed to meet the needs of disabled people reading etexts (Rello and Baeza-Yates, 2014).

Ereader accessibility evaluations have also been crowdsourced by the IDPF (Luceno, 2014) and demonstrate the need for an automatic evaluation tool that ereader application developers would benefit from, particularly because of the number of ereader applications already available in the mainstream marketplace. For existing app developers this would require revisiting their application and to use an accessibility evaluation tool to assess what needs to be retro-fitted. If, however, the accessibility evaluation tool is used from inception by the development team, this clearly would save time and unnecessary costs down stream.

Waddell *et al* state that a device is accessible if it can be used by a disabled person (Waddell et al., 2003). Maatta *et al*, maintain that the research on usable and functional aspects of a device are limited for print impaired users (Maatta and Laurie, 2014). Maatta *et al* suggest three examples of print impairment, namely: dyslexia; blindness and Visual Impairment (VI) (Maatta and Laurie, 2014). Awada *et al*, emphasise that the majority of accessibility research in this domain focuses on users with visual impairments (Awada et al., 2013).

Econtent, in much the same way as web content, relies on internal navigation of a documents semantic structure, by the user, through the use of metadata, such as heading tags (H1, H2, H3 etc.) as stipulated by the W3C (2008). Chan et al. provide an accessibility evaluation scoring system that has been developed to audit the accessibility of etextbooks used in HE (Chan et al., 2017). No known metric exists for an instrument that covers the entire HEI library ecosystem from discovery through to downloading and reading an etext for those with print impairments. Draffan suggests that there is also evidence that accessibility best practice work flows are being embedded from the outset within HEI library environments (Draffan et al., 2014). HEI libraries are clearly addressing accessibility but still require additional assistance from conversion tools, such as Sensus-Access, that convert inaccessible digital content to accessible alternative formats as referred to by Christensen et al. (2012). One patent exists and provides a framework for managing digital accessibility in HEI libraries, solely focusing on visual impairments as specified by Vitthal and Kumar (2017). These approaches do not integrate academic publishers and academic aggregators who distribute electronic catalogues to HEI libraries.

2.5 Chapter Summary

Based on the Ebook Access Bridge Model (McNaught et al., 2010), five new framework components have been specified in this research and are indicated in Figure 4. These components provide five categories for the user tasks required in an end-to-end process to search for, find, download, navigate and read etexts for those with print impairments in HE. Task orientated evaluations have been undertaken alongside expert reviews to test the accessibility and usability of a single evaluation tool that enables applications to be developed that are suitable for different mobile devices as referred to by Billi et al. (2010). However, what remains to be addressed is the task orientated evaluations using an HEI library mobile web portal against mobile device, UA and etext accessibility features.

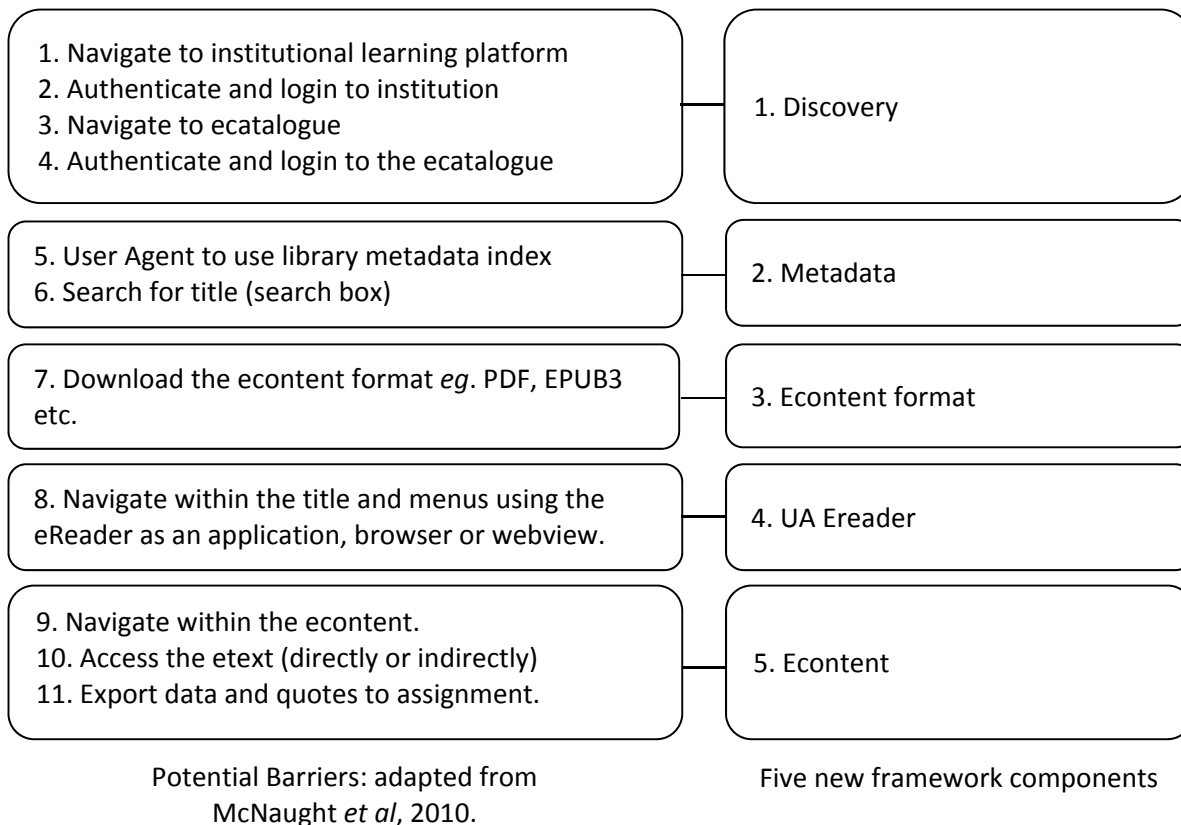


Figure 4: Five new framework components derived from an adapted model. Although evaluations have been undertaken for accessibility metadata through the use of RDTs, this research focuses solely on search metadata. The use of the HEI library mobile web portal on a mobile device for those with print impairments reading etexts falls within the five new framework components. In addition to this, both automatic and manual accessibility evaluations exist for web services, mobile web applications, hybrid mobile

applications, native applications and mobile devices. However, there is a paucity of research in this area particularly for accessibility, for example no published research findings could be found for evaluating the accessibility of mobile browsers as opposed to desktop/laptop browsers.

The published research findings for accessibility evaluations specific to mobile web and hybrid mobile applications are limited. Predominantly, the evaluations undertaken for mobile web applications have been for the visually impaired only, but there is research addressing this deficit for motor impairments (Trewin et al., 2013) and cognitive impairments (Chalkia et al., 2009, Yesilada et al., 2009). In terms of cognitive impairments, best practice and guidelines for the design of mobile ICT devices and their related applications is also available (ETSI, 2016).

One of the major issues with the current provision of these accessibility evaluation methodologies is that they are undertaken in isolation and need to be combined within a single framework and instrument, in this instance across the HEI library mobile web ecosystem for those with print impairments. If the mobile device can be integrated into this framework it has the potential to update the 10 year old Mobile Web Best Practice (MWBP 1.0). It also does not rely on third party device description repositories when retrieving mobile device features as was the case with research undertaken by Vigo et al. (2008). It exceeds this research by providing actual device feature evaluation through API accessibility support and the provision of etext accessibility metadata.

In the same way that the five new framework components provided categories for user tasks, additional physical and sensory control categories would be required for accessibility features available to mobile devices, ereader applications, mobile web browsers and etext formats. This would provide the means to produce an instrument and metric whereby HEI library ecosystem user tasks would be analysed against the availability of mobile web accessibility features. The outcome would be criteria that provide the means to automatically evaluate the mobile web accessibility of HE etexts for those with print impairments. This enabled a specification to be written for a mobile web accessibility evaluation tool.

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In order to achieve this, triangulation between the published research findings, the pre-evaluation (Patton, 1987) testing of physical mobile devices, UA and etext formats, and expert reviews to answer two separate research questions were required. The reason for this is that although published research findings provide peer reviewed research, relating to mobile web accessibility; they do not sufficiently cover all the aspects of accessibility that have been undertaken in the physical testing of devices and the manual testing of UAs and etext formats combined.

The pre-evaluations would require academic and student use case walkthroughs and a mapping of the core accessibility settings across mobile devices and UAs to support the first expert review. Each of the new framework components would be corroborated by undertaking the academic and student use case barrier walkthroughs.

Alongside this, it would be necessary to determine if the accessibility metadata for the PDF and EPUB3 formats could be programmatically detected. This would also include establishing the Application Programming Interface (API) accessibility support for device and mobile browsers and would enable the second expert review to be undertaken.

The first expert review (Expert Review One) would enable the physical and sensory control categories to be established and would require Thematic Analysis (Braun and Clarke, 2006) as the primary means of qualitative analysis and would answer research question one (RQ1).

RQ1: What physical and sensory control categories support automatically evaluating the mobile web accessibility of HE etexts for print impairments?

The second expert review (Expert Review Two) would be a manual evaluation of automatic BW success criteria generated by the instrument. This would be to heuristically evaluate a prototype (Van Velsen et al., 2008) and a walkthrough to determine if they work on an HEI library mobile web portal and on an academic publishers website. Analysis would be required to determine the results of standard Likert (Likert, 1932) scale questions. The provision of a complete framework, integrating the device, an instrument and metric would answer the second research question (RQ2).

RQ2: How does the mobile web accessibility of Higher Education electronic texts for print impairments need to be automatically evaluated?

One of the main outcomes of reviewing the published research findings was that the BW method was found to be more than an evaluation method. It is a tool that supports automatic and human evaluation. It enables web pages to be ranked and for websites to be compared for accessibility. Since this research concentrates on the use of HEI library mobile web portals, it would be necessary to analyse specific pages on a single portal ensuring this works before comparing multiple web portals.

The BW method has also been chosen because it can be extended to other user groups for analysis as stated by Yesilada et al. (2011). It is for the same reason that the BW method has been adopted for this research incorporating user groups impacted by print impairments. These include categories for visual impairments (including blindness), dyslexia, and physical difficulties (impacting dexterity and fine motor skills).

The application of the BW method is based on category specific user tasks and goals with user characteristics and settings that determine various separate scenarios. In this instance the scenarios relate specifically to using an HEI library web portal on a mobile device. This provides the basis for how the instrument is constructed.

Using the four new framework components for discovery, the econtent format, downloading formats and the ereader as the UA form the user tasks that are analysed against device settings relevant to print impairments. These were also mapped to situationally induced impairments, see Table 3, to ensure that environmental and activity based settings were covered.

Since UAs include web applications, mobile browsers and ereader applications use case scenarios relevant to print impairments are required. The instrument uses the BW method severity scoring, a 1-2-3 scale that denotes the level of accessibility. Another key finding from the published research findings was that specific stakeholders can be targeted from non-technical to expert evaluators, designers and developers as suggested by (Bandeira et al., 2010). Reviewing the published research findings indicated too that

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the key stakeholders within the HEI library ecosystem are academics/students, librarians, academic publishers and academic aggregators.

Table 3: Mapping print impairments to situationally induced impairments

adapted from Sarsenbayeva et al., 2017.

Print impairments	Situationally induced impairments (adapted from Sarsenbayeva et al, 2017)
Visual impairment (incl. blindness)	Ambient light Ambient noise (eg. using a screen reader)
Dyslexia (cognitive impairments)	Ambient noise (eg. using Text to Speech (TTS)) Emotional state of the user (eg. mood) Stress
Physical difficulties (motor impairments)	Ambient temperature (eg. Device operation in a cold environment) Mobile state of the user Encumbrance (eg. Carrying an object) Ambient noise (eg. using voice recognition).

Chapter 3 Methodology

This chapter explains how RQ1 and RQ2 relate to the five new framework components derived from an adapted model, as discussed in the background summary (see section 2.5), in preparation for the design and testing of an instrument. It also provides an overview of chapter's four to eight and indicates how each research question relates to the framework and instrument, and which chapters answer RQ1 and RQ2. The chapter starts by providing an overview of 13 research methods that are then reviewed to include the methods actually used in the research. It explains the use of triangulation between the published research findings, Expert Review One and Expert Review Two and the physical testing of mobile devices, UAs and etext formats (PDF & EPUB3).

This research uses inductive analysis and an exploratory approach for pre-evaluation data collection as defined by Patton (1987). It meant that a full quantitative evaluation of the instrument including its metric could not take place until an independent review by experts had been undertaken to determine if the instrument worked. Experts manually evaluated the automatic evaluation criteria based on print impairment accessibility requirements and in essence took the place of an automatic accessibility evaluation tool.

The purpose of the instrument evaluation by the individual experts was not a validation of a metric but to complete the framework and to determine if a prototype could be used. It also enabled the problems with the prototype to be determined by the experts rather than attempt to establish the quality of the prototype. This led to a demonstration of how to use specific accessibility metadata, a framework and an instrument.

The chapter also provides an overview of how the framework is incorporated into the instrument and indicates how the automatic BW success criteria generated by the instrument are used to develop a proof of concept tool for the extraction of accessibility metadata from a PDF. This then leads onto how this is incorporated into four stakeholder specific web applications and a web service in order for user centred accessibility evaluation to take place in the HEI library mobile web ecosystem for those with print impairments.

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Van Velsen et al focus specifically on adaptable and adaptive systems for user centred evaluation and have undertaken a review of the literature relating to the methods used in that domain (Van Velsen et al., 2008). It is for this reason that this research is used as a foundation for this chapter, while bringing in additional and/or more recent work to either corroborate or update the recommendations detailed in the Van Velsen review.

According to Van Velsen et al one major criticism of the literature was the limitations found in the systematic reporting of the methods undertaken and providing enough detail so that the study could be reproduced. Van Velsen et al refer to eight research methods found in their review of the literature, namely:

1. The use of prototypes versus simulation;
2. Laboratory and real-life observations;
3. Questionnaires;
4. Interviews;
5. Focus groups;
6. Data log analysis;
7. Think aloud protocols;
8. Expert reviews.

Van Velsen et al also refer to the use of quantitative and qualitative evaluation methods within the context of triangulation (Van Velsen et al., 2008).

3.1.1 Triangulation

Denzin generally defines triangulation as '*the combination of methodologies in the study of the same phenomenon*' (Denzin, 1978). Denzin also identifies four basic types of triangulation, namely:

1. Data: relating to time, space and person;
2. Investigator: involving either one observer or many for the same object;
3. Methodological: requiring within method and between method triangulation; and
4. Theory: requiring one perspective or many that relates to a set of identical objects (Denzin, 2017).

According to Denzin, the '*within method*' requires the use of multiple techniques when collecting and interpreting data within a given method. Whereas the '*between method*' refers to when multiple separate methods provide comparable data during cross validation (Denzin, 1978). Jick states that the archetypical strategy for triangulation is when complimentary methods are used improving the validity of results (Jick, 1979). Campbell and Fiske introduced the strategy that multiple methods are required in the validation process to ensure that the method does not impact what is being studied (Campbell and Fiske, 1959).

3.1.2 Quantitative evaluation methods

According to Creswell quantitative research questions are narrow and specific enabling observable and measurable data to be obtained. In order to collect quantitative data Creswell states that an instrument is used allowing the study variables to be measured. Creswell then provides a definition of an instrument in that it is '*a tool for measuring, observing, or documenting observable data*' and is prepared in advance prior to undertaking the study (Creswell, 2012). Examples of which include checklists, standardised tests and survey questionnaires as stipulated by Creswell (2012).

3.1.3 Qualitative evaluation methods

Patton states that qualitative methods include three types of data collection:

1. Interviews that are open ended and in-depth;
2. Direct observations; and
3. Open-ended written documents, such as questionnaires (Patton, 1987).

In addition to this Creswell argues that qualitative research lends itself to addressing a research problem when there are unknown variables and exploration is required (Creswell, 2012). According to Miles and Huberman the use of a conceptual/theoretical framework can lead to Thematic Analysis, by qualitatively coding surveys (Miles and Huberman, 1994). Miles and Huberman recommended that to test the reliability of Thematic Analysis a minimum of two coders is necessary and that agreement between the coders should be above '80%' (Miles and Huberman, 1994). Braun and Clarke suggest

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that Thematic Analysis should be the result of six stages, indicated in Table 4 (Braun and Clarke, 2006).

Table 4: Six Phases of Thematic Analysis adapted from Braun and Clarke, (2006).

'Stage	Description of the process
1. Familiarisation of data:	Transcribing data (if necessary), reading and re-reading the data, noting down initial ideas.
2. Generating initial codes:	Coding interesting features of the data in a systematic fashion across the entire data set, collating data relevant to each code.
3. Searching for themes:	Collating codes into potential themes, gathering all data relevant to each potential theme.
4. Reviewing themes:	Checking if the themes work in relation to the coded extracts (Level 1) and the entire data set (Level 2), generating a thematic 'map' of the analysis.
5. Defining and naming themes:	Ongoing analysis to refine the specifics of each theme, and the overall story the analysis tells, generating clear definitions and names for each theme.
6. Producing the report:	The final opportunity for analysis. Selection of vivid, compelling extract examples, final analysis of selected extracts, relating back the analysis to the research question and literature, producing a scholarly report of the analysis.'

Gelo et al argue that a qualitative approach is inductive; whereas a deductive approach is quantitative (Gelo et al., 2008). Thomas maintains that using an inductive approach (bottom up), enables the emergence of research findings; whereas the deductive approach (top down), is based on determining how reliable data is against previous assumptions, theories or hypotheses (Thomas, 2006).

Tashakkori et al. state that when both quantitative and qualitative methods are combined this is referred to as a mixed method design (Tashakkori et al., 1998). Creswell argues that the core tenet of a mixed method approach is that a research problem is better understood through the combination of both quantitative and qualitative data analysis rather than in isolation (Creswell, 2012).

3.1.4 Exploratory evaluation research

According to Patton if insufficient information is available that permits quantitative measures from being used, then exploratory research is undertaken. Patton argues that this form of exploration is based on naturalistic enquiry, including inductive analysis and qualitative data collection. Patton also states that the evaluation of exploratory data collection may be referred to as pre-evaluation since this occurs prior to formal evaluation through the use of a quantitative instrument (Patton, 1987).

3.1.5 Published research findings

Creswell maintains that the premise for using the literature review in quantitative research is different to that of qualitative research. In quantitative research Creswell suggests that the literature review is substantial and steers the research, whereas qualitative research is more reliant on being steered from the participant's viewpoint. (Creswell, 2012).

In this thesis the review of the published research findings is referred to as the background because it includes all forms of literature, including those that refer to software development. Dybå and Dingsøyr provide a full empirical systematic review methodology that was specific to software development (Dybå and Dingsøyr, 2008). Booth, however, states that a systematic approach to a literature review can be used instead of a full systematic review (Booth et al., 2012).

3.1.6 Laboratory and real-life observations

Van Velsen et al suggest that a laboratory affords a controlled environment enabling a researcher to reduce extraneous variables. The validity of the research undertaken in the laboratory, however, may have issues with generalisation since the laboratory environment is not a real-life setting as stipulated by Van Velsen et al. (2008). Real life observations occur when a researcher notes interesting events while watching a participant undertake an activity, these sessions may also be recorded (Van Velsen et al., 2008) enabling the researcher to revisit the findings.

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For the purposes of this thesis physical device testing was categorised under real life observations. Whitehouse undertook physical device testing and referred to it as hands-on evaluation (Whitehouse, 2011). Whitehouse did not, however, refer to the strengths or the weaknesses of such a method. Using this method it was possible to undertake manual tests of UAs that included mobile browsers and ereader applications during run time while testing the devices. In doing so this provides empirical information about device accessibility settings. There are two drawbacks with this approach namely the time taken to undertake an evaluation and the availability of devices.

3.1.7 Prototypes

Van Velsen et al argue that in order for an evaluation of a system to be undertaken it is necessary for interaction to take place between the subject and a prototype (Van Velsen et al., 2008). Vigo and Brajnik, refer to '*user adapted interaction*' and discuss validity as accessibility in use and reliability by deploying a single accessibility tool or prototype (Vigo and Brajnik, 2011). Van Velsen et al indicate that a working prototype of a system was used more than computer simulation, and that high fidelity prototyping and questionnaires are used for problem detection (Van Velsen et al., 2008).

Van Velsen et al stipulate that low fidelity prototypes are not always representative of a final version because there are a limited number of screenshots for the system. In addition to this, Van Velsen et al state that user feedback may be abstract because of abstraction in paper prototyping (Van Velsen et al., 2008).

3.1.8 Questionnaires

Van Velsen et al define a questionnaire as the collection of data, whether via a screen or on paper, by allowing respondents to answer specific questions. In addition to this the questionnaires may be open or closed (Van Velsen et al., 2008). Open responses enable participants to answer freely in writing, whereas closed responses allow participants to select answers from multiple choice options as specified by Van Velsen et al. (2008). Van Velsen et al maintain that closed items are limited to the confirmation of known variables in order to assess scoring (Van Velsen et al., 2008).

Van Velsen et al, state that questionnaires were used the greatest number of times within the literature. In addition to this Van Velsen et al recommend that the questionnaire is published alongside the study and also online (Van Velsen et al., 2008).

Creswell refers to the use of survey designs for quantitative research and states that this procedure involves the administration of a questionnaire or survey that is typically presented to a sample group of participants. In addition to this Creswell argues that this process identifies large group characteristics, attitudinal trends, behaviours and opinions (Creswell, 2012).

Van Velsen et al, state that questionnaires can be used for quantitative measurement, suggesting the use of Likert scales to gather data on variables such as '*appreciation of personalisation*', '*user satisfaction*', '*general opinions about the system*' and '*benchmarking purposes*' (Van Velsen et al., 2008). Van Velsen et al maintain that using previous questionnaires may lead to the development of a standard quantitative instrument (Van Velsen et al., 2008). Van Velsen et al also stipulate that to verify quality a larger core group of participants is required whereas a smaller group can be used to determine problems (Van Velsen et al., 2008).

3.1.9 Interviews

Van Velsen et al state that interviews are typically where an interviewer asks participants questions. These can be semi-structured allowing for ad hoc questioning by the interviewer and structured with a fixed set of questions as specified by Van Velsen et al. (2008). In addition to this Van Velsen et al recommend capturing comments typically made by participants as best practice (Van Velsen et al., 2008). According to Van Velsen et al interviews enable the '*perceived usefulness*' and '*intention to use*' to be identified. In addition to this Van Velsen et al maintain that qualitative methods, including interviews and focus groups, enable aspects such as '*appreciation*', '*future system adoption*' and '*perceived usefulness*' to be determined (Van Velsen et al., 2008).

3.1.10 Focus groups

According to Van Velsen et al a moderator leads the discussion in a group where participants taking part discuss questions or specific topics. Van Velsen et al also suggests that this is useful because the moderator can ask ad hoc questions to probe specific areas of interest (Van Velsen et al., 2008). One problem with focus groups, as stated by Van Van Velsen et al, is that the discussion topics are predominantly impacted by the moderator and limited to these topics (Van Velsen et al., 2008). However, Van Velsen et al maintain that the benefits of focus groups is that this method provides greater '*understanding of user behaviour*' alongside other factors such as '*intention to use*' and '*appreciation*' (Van Velsen et al., 2008).

3.1.11 Data logs

Van Velsen et al state that data logs are the recorded actions of a users interaction with a system and can be used for both qualitative and quantitative analysis. This analysis maybe specific to the users performance or behaviour (Van Velsen et al., 2008). Data logs can also be used unobtrusively and provide an objective record of behaviour for analysis as suggested by Van Velsen et al. (2008). Van Velsen et al recommend that when analysing data logs this is undertaken in conjunction with qualitative methods such as focus groups and think aloud protocols (Van Velsen et al., 2008).

3.1.12 Think aloud

Van Velsen et al state that during a think aloud protocol participants typically speak out aloud expressing their own thoughts about a system in use (Van Velsen et al., 2008). Surveys are not necessarily appropriate for usability evaluations, and qualitative evaluation methods such as thinking aloud are applicable as specified by Van Velsen (2007). According to Van Velsen et al the rationale implemented by a user can be revealed through the use of think aloud protocols providing a useful means to understand user behaviour (Van Velsen et al., 2008).

3.1.13 Expert reviews

Although, not applied so much throughout published research, Van Velsen et al include expert reviews as a valid method and state that they can be used as a means to gather the opinions of an expert evaluator (Van Velsen et al., 2008). In tandem with this, Brajnik et al state that the number of times expert evaluators agree, determines a value for agreement (Brajnik et al., 2011).

According to Nielsen and Molich diminishing returns are reached with aggregates of approximately 10 expert evaluators (Nielsen and Molich, 1990). Hwang and Salvendy corroborate these findings by referring to a 10 plus or minus two rule (Hwang and Salvendy, 2010). This suggests that no less than eight expert evaluators would be able to provide a statistically significant result when reviewing heuristic walkthrough criteria. In contrast it also suggests that to have more than 12 expert evaluators diminishing returns would again become evident.

Since there is an overlap between the usability and accessibility of websites as argued by Petrie and Kheir (2007), the number of experts required for usability heuristic evaluation were taken as the same in the mobile web domain for identifying accessibility problems (Brajnik et al., 2011). According to Brajnik et al, reproducibility stabilises with over five expert reviewers and that every problem can be found with three experts (Brajnik et al., 2011). According to Brajnik *et al* determining actual expertise yields more useful information and enables results to have greater validity (Brajnik et al., 2011).

This is in contrast to the findings of Nielsen and Molich who state that only two thirds of the problems can be found with five expert evaluators (Nielsen and Molich, 1990). It is for this reason that the lower limit, of 8 expert evaluators for heuristic evaluation, expressed by Hwang and Salvendy (2010), were set as the limit for this research. Van Velsen et al stipulate that replication of an evaluation was impeded if it had not been sufficiently specified and state that this has minimal empirical value (Van Velsen et al., 2008).

According to Van Velsen et al the benefits of using heuristic evaluation or expert review is that specific topics can be evaluated. Whereas conducting user studies provides results

that exceed those that can be obtained through expert review because the context and variation in characteristics are addressed (Van Velsen et al., 2008).

3.2 Research methods review

Triangulation was used between the complimentary methods of published research findings, the physical testing of mobile devices, etext formats and two expert reviews, see Figure 5. The reason for this was because complimentary methods typically provide valid results and are the leading strategy for triangulation as stated by Jick (1979). Denzin argues that between complimentary methods provide congruent comparable data (Denzin, 1978) and was the reason why this strategy was adopted.

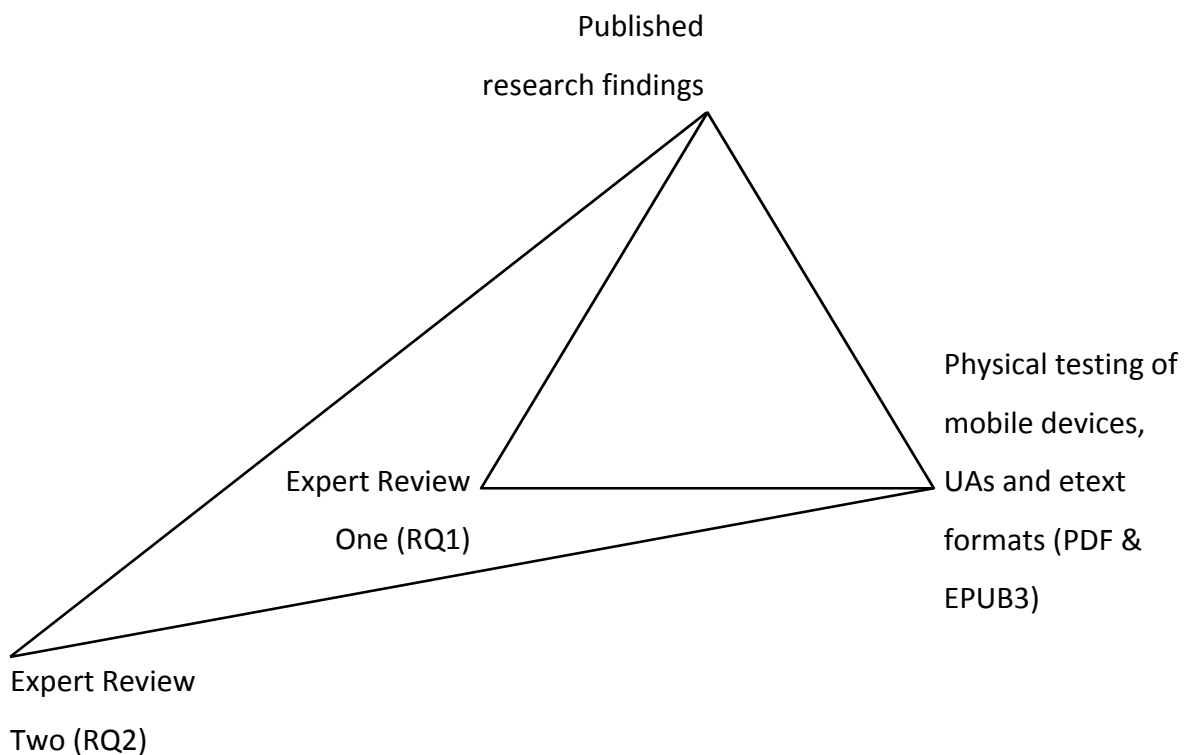


Figure 5: Triangulation between the published research findings, expert reviews and the physical testing of mobile devices, UAs and etext formats.

The published research findings required searches to be undertaken that adhered to a systematic approach (Booth et al., 2012), rather than a full systematic review. The reason for this was that although published research findings provided peer reviewed research

relating to mobile web accessibility; they did not sufficiently cover all the aspects of accessibility that were undertaken in the physical testing of devices and the manual testing of UAs and etext formats combined. Relevant academic databases were also searched (Dybå and Dingsøy, 2008) alongside ad hoc searches for seminal work and technical specifications and standards that affect digital accessibility within the HEI library ecosystem.

For example, this included standards used by academic publishers such as the Adobe Portable Data Format, more commonly referred to as the PDF, and the IDPF EPUB3 standard. Relevant studies were identified based on reading respective paper titles and abstracts, and once shortlisted the primary studies were critically appraised as recommended by Dybå and Dingsøy (2008).

This research combines methodologies that relate to automatically evaluating the mobile web accessibility of Higher Education electronic texts for those with print impairments. Although survey design, a type of quantitative research, was used in both expert reviews to support the development of the framework, instrument and metric; the instrument and metric could not undergo a full quantitative analysis.

The reason for this was because the instrument indicated that there was potentially over 400 automatic BW success criteria to analyse. It was, therefore, unrealistic to expect individual expert responses for this number of success criteria and why a representative sample were selected for the review.

Another issue was that each component of the instrument required further testing as it was unclear what all the variables were and that further exploration was required. Patton maintains that when there is insufficient information to permit the use of quantitative measures that exploratory research relies on three methods involving inductive analysis, naturalistic inquiry and qualitative data collection (Patton, 1987).

In addition to and prior to each of the expert reviews taking place additional exploratory evaluation data was collected in order to inform the development of the instrument. It was for this reason that Expert Review One required:

1. Academic and student use case walkthroughs; to be undertaken alongside

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2. The mapping of core accessibility settings across mobile devices and UAs within an HEI library mobile web ecosystem; and

Expert Review Two required:

1. Establishing whether PDF and EPUB3 accessibility metadata could be programmatically determined by AT; and
2. Determining what device and mobile browser API accessibility support was available.

As can be seen, this additional exploration involved physical device testing and is referred to by Whitehouse as hands-on evaluation (Whitehouse, 2011); and by extension this also included mobile web accessibility evaluations. The physical testing of mobile devices included the manual testing of UAs and etext formats downloaded or pre-loaded respectively onto smartphone devices. The physical device testing used the work undertaken by (Swan, 2015) to cover the accessibility testing of the Android device.

This was alongside the use of the BBC mobile guidelines (BBC, 2017) and recommendations from Juicy Studio regarding the issue of testing colour contrast with screenshots (Lemon, 2017). In addition to this the Adobe best practice guidelines for PDF accessibility state that colour contrast and reading order need to be checked manually (Adobe, 2012). The UAs, in this instance, were ereader applications, mobile browsers and online ereaders. Part of this evaluation process also included the careful exploration of an HEI library web portal on mobile devices.

Since physical devices were tested it fell within the category of real life observations and was the reason why a laboratory setting was not required. Patton also suggests that evaluating exploratory data collection is a precursor to full quantitative analysis of an instrument and refers to this as pre-evaluation (Patton, 1987). The expert reviews were also not undertaken under laboratory conditions because recruitment of the experts was nationwide in the UK and in different parts of Europe.

It was for this reason that both an inductive and an exploratory approach were implemented for this research, with a view to providing a pre-evaluation of the framework and instrument. Gelo et al posit that an inductive approach is qualitative (Gelo

et al., 2008) and Creswell argues that qualitative research is reliant on the views of participants rather than selected published research findings by the researcher giving the research questions a specific direction (Creswell, 2012). This was important for two reasons.

Firstly, this emphasised the individual expert participants and their pivotal role within this research as independent reviewers. Secondly, although published research findings provided peer reviewed research relating to mobile web accessibility; they did not sufficiently cover all the aspects of accessibility that were undertaken in the physical testing of devices and the manual testing of UAs and etext formats combined.

It was for this reason that the published research findings used searches that adhered to a systematic approach, rather than a full systematic review as suggested by Booth et al. (2012). In order to maintain the quality of the published research findings an abridged version of the Critical Appraisal Skills Programme (CASP) systematic review methodology as outlined by Dybå and Dingsøyr (2008) was implemented.

In addition to this, five new framework components were derived from an adapted model in the published research findings. Miles and Huberman state that the use of a conceptual/theoretical framework can lead to Thematic Analysis, by qualitatively coding surveys (Miles and Huberman, 1994). It was because of this that Thematic Analysis was undertaken during Expert Review One. Thematic Analysis enabled the physical and sensory control categories for print impairments to be determined. The control categories incorporated issues arising for dyslexia, a form of cognitive impairment.

Two expert reviews were undertaken: Expert Review One (ERGO/FPSE/18699) required thematic analysis as the primary means of evaluation; whereas Expert Review Two (ERGO/FPSE/30291) required the independent expert review of a prototype and walkthrough based on automatic BW success criteria. Both Expert Review One and Expert Review Two were supported by pre-evaluation as suggested by Patton (1987). This was important because each component of the framework needed to be tested and then incorporated into the instrument. The pre-evaluation that took place for Expert Review One required two forms of analysis. Firstly, an academic and student use case walkthrough, and secondly a mapping of core accessibility settings across three

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mainstream mobile devices and 10 UAs. Expert Review Two required a thorough investigation of accessibility metadata and its availability for both the PDF and EPUB3 formats to assess whether they could be programmatically determined. This was undertaken alongside a careful review of device and mobile browser API accessibility support. For example, checking for a full screen API such as those currently being developed by (van Kesteren, 2019) and referred to in the Mozilla library (Mozilla, 2018).

Expert Review One combined with the academic and student use case walkthroughs and the mapping of core accessibility settings completed the framework. This was in preparation for a prototype and determining whether it could be used. In stage six of Thematic Analysis namely 'Producing the report', the qualitative analysis relates back to the published research findings and in so doing completes triangulation for Expert Review One. The same approach was undertaken for the qualitative and quantitative analysis for Expert Review Two.

Expert Review Two concentrated on the development of the instrument and to demonstrate how to use the accessibility metadata, framework and instrument. Although a metric was developed it was not the intention of this research to validate it and will follow as part of future work when a working application has been developed for on device testing. Both expert reviews provided the means to independently evaluate the framework, the instrument and a prototype.

The reason expert reviews were implemented was because Van Velsen et al suggest that heuristics can be used to evaluate topics such as accessibility (Van Velsen et al., 2008). The evaluation of the instrument had to focus on potential problems rather than its quality because it was still in the development phase. Van Velsen et al argue that in order to verify quality, a large '*representative group of respondents*' is required; whereas problem detection is possible using a relatively small sample (Van Velsen et al., 2008).

Both expert reviews implemented questionnaires because Van Velsen et al suggest that effective questionnaires typically provide useful insights that enable standard quantitative instruments to be constructed (Van Velsen et al., 2008). Van Velsen et al do, however, provide a caveat in that these need to be based on past questionnaires (Van Velsen et al., 2008). Spector also maintain that questionnaires require appropriate scales

(Spector and Sage Publications, 1992); and as Van Velsen et al suggest Likert scales can be used for quantitative measurement when collecting data relating to '*general opinions*' about a system (Van Velsen et al., 2008). Social desirability bias, where a participant presents themselves in a favourable way when answering a questionnaire (Trewin et al., 2015) was also reduced through the use of an online anonymous survey as recommended by Richman et al. (1999).

Van Velsen et al maintain that questionnaires are commonly applied as a method for gathering evaluation data for adaptive and adaptable systems (Van Velsen et al., 2008). These were the reasons why both questionnaires and Likert scales were used in the expert reviews. Patton et al also state that by using open ended questionnaires qualitative data can be collected (Patton, 1987) and is why open ended questions were stated in the expert review questionnaires.

In addition to questionnaires a working prototype of a mobile web accessibility evaluation tool, that also allows ereading to take place, was used instead of computer simulation. The reason for this was because Van Velsen et al state that a working prototype of a system was used more than computer simulation (Van Velsen et al., 2008). The reason why high fidelity prototyping and questionnaires were used is that Van Velsen et al state that these can be used for problem detection (Van Velsen et al., 2008).

This was also the reason why a prototyping tool developed by Invision was used to produce high fidelity prototypes. Van Velsen et al argue that low fidelity prototypes typically include a limited number of system screen shots that do not necessarily represent the final version of a system (Van Velsen et al., 2008). Van Velsen et al also suggest that abstract user feedback may be the result of abstract paper prototypes (Van Velsen et al., 2008).

In order to create the high fidelity prototypes a specification was written based on the automatic mobile web accessibility BW success criteria generated by the instrument. The purpose of the evaluation of the instrument was not a validation of the metric but to complete the framework and to find out if a prototype could be used. This was then followed by a demonstration of how to use the accessibility metadata, the framework and the instrument.

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This then enabled a wireframe to be designed for the prototype and the entire mobile web accessibility evaluation tool. This tool was specifically designed for four stakeholders, namely:

1. Academic or student users who are print impaired;
2. HEI Librarians;
3. Academic publishers; and
4. Academic aggregators.

This led to the development of a proof of concept tool that extracted accessibility metadata from a PDF using a web service.

The reason interviews, focus groups, think aloud methods were not implemented was twofold. Firstly, that participants were approached nationwide in the UK and elsewhere in Europe. It would have been impractical and costly to implement these methods in this instance. Secondly, an independent expert review was required to determine if the instrument automatic BW success criteria and the prototype would work on an HEI library web portal using a mobile device prior to user testing.

The user testing would be part of future work requiring the involvement of disabled people when testing a working version of the mobile web accessibility application on a mobile device. Another aspect that prevented user testing by disabled people was that the prototyping tool developed by Invision was inaccessible. This also prevented disabled experts from being able to take part in the expert review.

User behaviour analytics (UBA) relates to data log analysis, and although considered as a potential method for data gathering this was impeded by obtaining permissions from mobile devices and UAs. It would also require a working application for on device testing. This is unfortunate because this method provides usage data about accessibility settings but relies completely on the user enabling permissions.

3.3 Research questions

Expert Review One was designed to identify physical and sensory control categories that support evaluating the mobile web accessibility of HE etexts for those with print

impairments. The key accessibility requirement of simplification of controls for dyslexic academic or student users (Rello, 2014) was incorporated in the combination of the physical and sensory control categories for the purposes of this research. In determining the physical and sensory control categories this answered research question one (RQ1).

RQ1: What physical and sensory control categories support automatically evaluating the mobile web accessibility of Higher Education electronic texts for print impairments?

In answering RQ1, the first iteration of an automatic accessibility evaluation framework (mentioned in Chapter 4) was created at this stage in the research, and would be the basis for an instrument. Thematic analysis was the primary means to answer RQ1 based on the qualitative statements made by the participants in Expert Review One.

Van Velsen et al maintain that questionnaires are commonly applied as a method for gathering evaluation data for adaptive and adaptable systems. RQ1 and RQ2 were answered by using this method, although for RQ2 (Expert Review Two), an online survey was sent out because the participants came from around Europe. It would have been impractical and costly to use focus groups and interviews in this instance.

Van Velsen et al also state that questionnaires can be used for quantitative measurement, suggesting the use of Likert scales to gather data on variables such as '*general opinions*' and '*benchmarking purposes*' (Van Velsen et al., 2008). Brajnik and Harper refer to validity (accuracy) and reliability (repeatability), in particular: validity as accessibility in use and reliability by deploying a single accessibility tool or prototype (Brajnik and Harper, 2016).

Once the control categories were determined by the individual experts, then and only then could research question two be answered. Expert Review Two was undertaken to be independently reviewed, a requirement suggested by Shaw (2002). The automatic BW success criteria, generated by the instrument, was used by the individual experts to evaluate a prototype tool. In doing so this answered research question two (RQ2), the overall aim of this research.

RQ2: How does the mobile web accessibility of Higher Education electronic texts for print impairments need to be automatically evaluated?

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Clegg-Vinell et al indicate that to completely embrace a user centred approach within mobile web accessibility is a significant undertaking. The reason for this is the diversity and range of impairment types (Clegg-Vinell et al., 2014) resulting in often co-occurring functional difficulties due to the present design, delivery and interaction used for accessing mobile content.

The ongoing updates and developments for mobile devices and mobile UAs and the constant evolution of mobile and web accessibility guidelines (Clegg-Vinell et al., 2014). To encourage independent access, reduce time constraints and costs, an automatic method for producing mobile web accessibility evaluations of etexts within the HE ecosystem is suggested.

Particularly within an end-to-end process that requires print impaired academics and students to undertake specific user tasks. These tasks, and potential accessibility barriers, require the user to navigate through an HEI library web portal on a mobile device so that, for example a core academic etext, provided in the PDF format, can be downloaded, navigated and read on a mobile device. Patton also maintains that process evaluations are inductive in that they explore how an outcome occurs instead of focusing on the product itself (Patton, 1987).

The outcome of the instrument and metric provided automatic BW success criteria that can be used to write a specification for mobile web accessibility evaluation tool. This evaluation tool can then in turn be used during the development and design lifecycle of a web service and four separate web applications that enable stakeholder interaction.

This interactions takes place between the academic or student, HEI librarian, academic publisher and academic aggregator. A wireframe is provided for each separate use case, and includes provision for a lite version of the academic or student application as well as a branded HEI library version of the application. This service will also provide real-time data about the demand for accessible digital publications within HEI libraries, helping to inform the academic publishing sector.

The main outcome of this research was the discovery of the extent to which accessibility metadata can be exposed across mobile devices, mobile ereader applications, mobile

browsers and eformats downloaded onto mobile devices. Figure 6, provides an overview and indicates how each research question relates to this final outcome and which chapters answer RQ1 and RQ2.

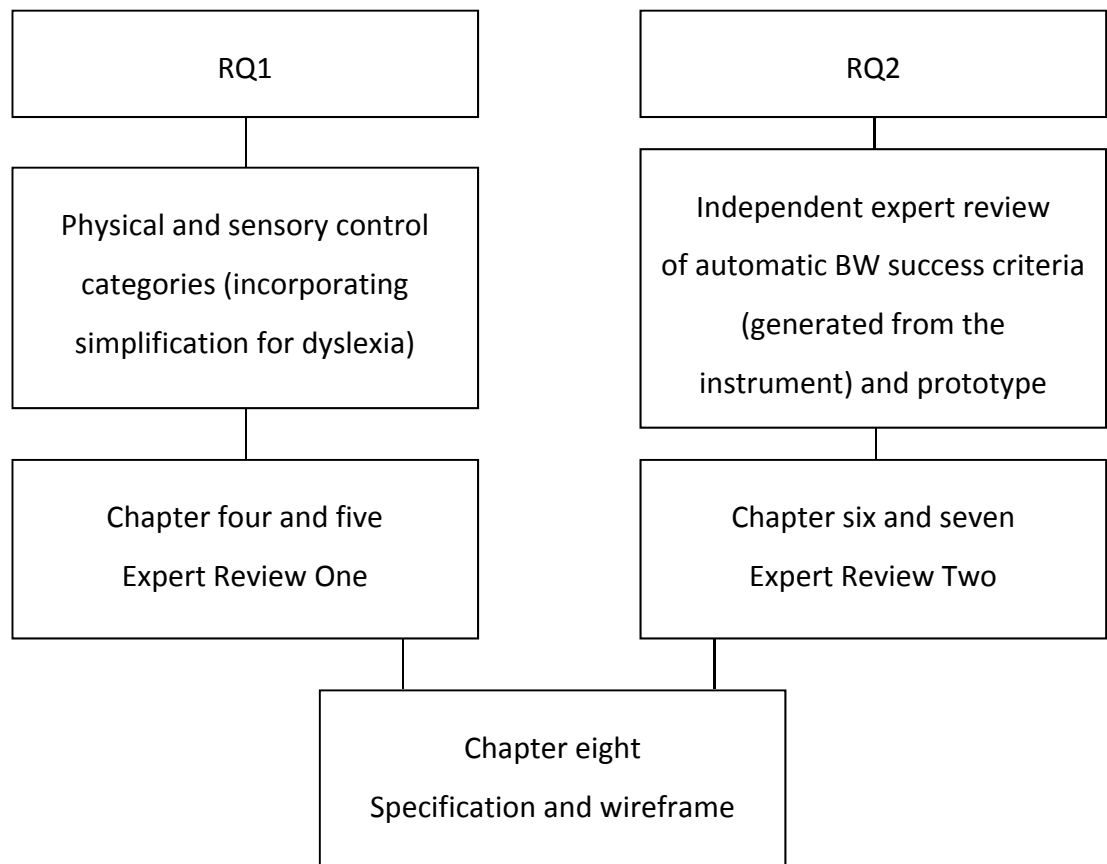


Figure 6: How RQ1 and RQ2 relate to chapters four, five, six, seven and eight.

3.4 Overview of chapters four to eight

In an end-to-end process print impaired academics and students need to undertake specific user tasks to navigate through an HEI library web portal on a mobile device to download, navigate and read a required academic etext, such as a journal paper published in a PDF format. For example, one key task is that of authentication when logging in to the HEI library web portal. If this task is inaccessible, this creates an accessibility barrier for that user. The user tasks need to be evaluated against the mobile device, mobile ereader application and mobile browser accessibility features. These features, or selectors, are more commonly referred to as settings.

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The outcome of the user tasks against the accessibility settings provided the automatic BW success criteria. These criteria have been used to inform the writing of a specification for a mobile web accessibility evaluation tool to be used by designers, developers that could also be repurposed for HEI librarians, academic publishers, academic aggregators and print impaired academic or student users. The manual device and UA pre-evaluations supporting the development process for producing the automatic accessibility evaluation framework, physical and sensory control categories and the instrument were evaluated through an independent expert review.

3.4.1 Chapter 4: Identifying physical and sensory control categories

Chapter four provides each stage of how RQ1 was answered. The testing stages included academic and student use case walkthrough and a mapping of core accessibility settings across mobile devices and user agents. This is then followed by explaining the method used for Expert Review One. The results are provided for the pre-evaluation stage that then lead into the results for Expert Review One concluding with a summary for the review. The primary means of analysis for Expert Review One was through Thematic Analysis as suggested by (Braun and Clarke, 2006).

RQ1 was answered, in chapter four, by using the Thematic Analysis of Expert Review One qualitative statements. In total 12 expert participants (n=12) agreed to take part in the review with the use of semi structured questionnaires that formed a survey to determine the opinions of the individual experts. The subjective knowledge of the individual experts was determined by asking each participant to answer questions that had a range of variables relevant to gauging expertise.

For example, the participants were asked to provide a subjective knowledge rating on a Likert scale of one to five. The participants were then required to indicate their level of experience across five different year ranges. The final group of expertise questions related to whether the expert had tested websites, UAs and mobile devices for accessibility and had used an ereader for reading academic etexts.

This enabled a cross check to be undertaken between the qualitative statements made by the individual experts for two separate open ended questions and the expertise of each

participant reinforcing the themes identified during analysis. The two questions referred to establishing what the functional categories were for accessibility settings and what the principles were behind those categories. The more experienced evaluators provided the core themes for these two questions; whereas the less experienced evaluators corroborated these main themes by identifying the sub themes within them.

The development process of Expert Review One required pre-evaluation (Patton, 1987) analysis through the use of academic and student use case walkthroughs. Alongside this was the mapping of core accessibility settings across mobile devices and UAs. The UAs included 10 mobile ereader applications, three cross platform mobile web browsers and three online readers, one of which included the mobile browser plugin the Firefox PDF cloud viewer.

The academic and student use case walkthroughs corroborated the five new components of an accessibility evaluation framework, these were the Discovery of academic etexts via an HEI library mobile web portal, the accessibility metadata represented by API calls and specific coding tags, the econtent format, such as PDF and EPUB3, the ereader that holds the content and the content itself (see Figure 7).

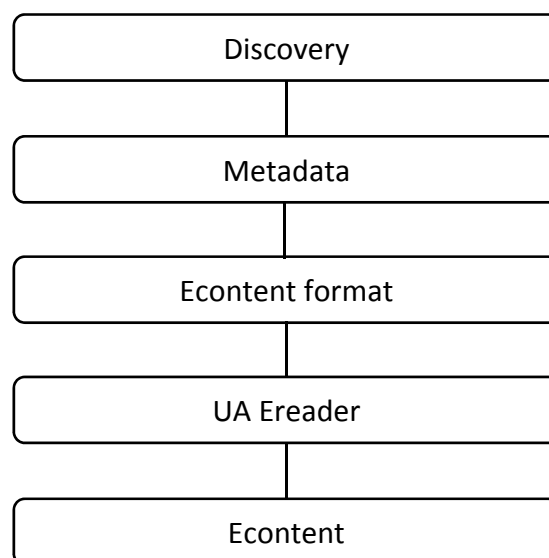


Figure 7: Five new accessibility evaluation framework components corroborated by the use case walkthroughs.

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This framework provided the basis for an instrument and metric that would be able to evaluate the mobile web accessibility of HE etexts for those with print impairments.

During the use case walkthroughs, it was realised that automatic BW success criteria were emerging for the mobile web accessibility HE etext domain. The use case walkthroughs were undertaken for each type of print impairment that identified respective accessibility requirements. These were for visual impairments, including blindness; dyslexia, a form of cognitive impairment; and motor impairments, such as fine motor control and dexterity.

The mapping of core accessibility settings across mobile devices and UAs required a thorough exploration of the ecosystem through physical device testing as referred to by Whitehouse (2011) and manual UA checks. The device mappings occurred across three main mobile platforms, the Android, iOS and Windows smartphones. Whereas the UA mappings were undertaken across ereader applications, that were recognised for their accessibility features. Chrome, Firefox and Opera mobile were chosen because they were cross platform and were assessed alongside the accessibility features of two online readers, Radium and the Bureau van Dijk Reader.

This process enabled the integration of a device into the framework and helped to address the ten year old W3C Mobile Web Best Practice basic guidelines (MWBP 1.0). This was in response to a request made by Kaur and Dani (2017). Once this had been completed it was possible to undertake Expert Review One. Expert Review One identified four physical and sensory control categories through thematic analysis, namely:

1. Visual controls;
2. Touch controls;
3. Audio controls; and
4. Voice controls.

In order to incorporate controls for dyslexia there were two possibilities; either the creation of a fifth category and refer to it as cognitive controls or to achieve this through a combination of the physical and sensory controls. It was this latter option that was used because five features relating to dyslexia were incorporated into the instrument. For example, controls for simplification, an essential accessibility requirement for dyslexia (Rello, 2014), took the form of decluttering. One of the controls for this was to include a

full screen mode, so that only the text to be read was visible, and no other navigational or menu items were shown on the screen. However, Text to Speech (TTS), may also be required in the form of read along, a control feature provided by UAs such as the VoiceDream Reader. So it can be seen that in this instance both visual and audio controls are required to meet the accessibility needs for decluttering and using TTS simultaneously.

In addition to this, the principles behind the physical and sensory control categories were also determined during this review. For example, it was ascertained that the principles behind the control categories may be influenced by the label of the user's disability. This includes the functionality the user is attempting to improve through the use of a mobile device when reading an etext downloaded from an HEI web portal.

The functionality referred to here is the outcome of the user tasks against the mobile device, ereader application, mobile browser and online reader accessibility settings and is triggered by the user (W3C, 2018). This enabled the next stage of the research to be undertaken, by investigating a means to determine how to automatically evaluate this process. This was achieved through the development of an instrument that provided automatic BW success criteria that could be used to develop an automatic accessibility evaluation tool.

3.4.2 Chapter 5: Identifying physical and sensory control categories results and discussion

Chapter five identifies 24 core accessibility settings across mobile devices and UAs. This was achieved by using a technology neutral approach to mobile web accessibility evaluation. This work also exposed the fact that the Windows 8.1 mobile phone did not support certain core accessibility features at the time of writing. For example, the most predominant was the lack of support for Switch Access Control, an accessibility feature used by those with motor impairments.

The technology neutral core accessibility features were mapped directly against both the physical and sensory device control categories and the five new framework components.

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This then enabled the relevance of specific accessibility features to be determined for HEI ereading when using a mobile device.

The chapter then determines what ereader application and mobile browser were to be used for the academic and student use case walkthroughs. This was achieved by shortlisting ereader applications based on their support of the PDF and EPUB3 formats. The list was reduced still further by determining what ereader applications supported the Android, iOS and Windows mobile operating systems. In doing so this enabled the core technology neutral core accessibility settings to be determined across 10 ereaders, the Chrome, Firefox and Opera mobile browsers and the available accessibility features for online ereaders. This included Radium and the Bureau Van Dijk Readers. One of the key findings from this was that the Bluefire Reader application was found to provide accessibility metadata within the application proving this can be presented in human readable form.

The VoiceDream Reader and Firefox mobile browser, at the time of writing, were found to be the most appropriate UAs to be used for the academic and student use case walkthroughs. Undertaking the use case walkthroughs helped to determine the number of steps involved in the process of searching for, finding, downloading, navigating and reading HE etexts. Each step required a user task and was a potential barrier. The total number of potential barriers, based on print impairment type, were then mapped against the five new framework components. In doing so this saw the emergence of an instrument and metric. This then enabled Expert Review One to be undertaken.

The aim of Expert Review One was to determine the physical and sensory control categories through the use of a survey that was presented to accessibility specialists in the alt-format domain. Demographics and actual expertise data were collected in order to determine what an expert was with the outcome that having less than two years' experience meant the participant's data was removed from the study. The physical and sensory control category comments made by the individual experts were mapped to expertise. This reinforced the findings of the Thematic Analysis undertaken in that the most experienced experts provided the key themes whereas the less experienced experts provided secondary themes that supported these key themes.

The outcome of this work was four physical and sensory control categories, integrating the device into the five new framework components. It also addresses the now 10 year old Mobile Web Best Practice (MWBP 1.0) guidelines. This is then followed by a discussion and limitations of the review. The chapter then concludes with a summary that then explains how the results of the review were taken forward. It also describes the changes made and how this helped the development of the thesis work.

3.4.3 Chapter 6: Development of the instrument

Chapter six provides each stage of how RQ2 was answered. The chapter begins with the design of the pre-evaluation (Patton, 1987) testing stages that determine whether the accessibility metadata for both the PDF and EPUB3 can be detected programmatically. This was achieved by searching through existing standards for both the PDF and EPUB3. In addition to this the device and mobile browser API accessibility support was also determined by searching through API libraries online. The chapter then explains the method used for Expert Review Two. RQ2 was answered, in chapter six, through the use of an independent expert review of the instrument in Expert Review Two. The expert review was required in order to provide an independent review of the automatic BW success criteria.

In total 8 expert participants (n=8) agreed to take part in Expert Review Two through the use of semi structured anonymous questionnaires undertaken online using the University of Southampton's official data collecting tool iSurvey. Data relating to the subjective knowledge and expertise of the participants was again collected during Expert Review Two. In doing so this helped to identify an issue related to the confusion over the difference between mobile accessibility and mobile web accessibility, at least for the less experienced expert reviewers.

Two Likert scale questions then followed relating to whether a prototype and automatic BW success criteria, generated by the instrument, would work on an HEI library web portal and an academic publishers website. The automatic BW success criteria were generated from the instrument by the outcome of analysing the user tasks against the accessibility features of the mobile device, mobile ereader application and mobile web

browser. The automatic BW success criteria were provided in an abridged form in Expert Review Two, this was to reduce the amount of time required by the reviewers to undertake the review. In addition to this, a metric was also produced for the instrument that measured the overall accessibility support provided by each component. The academic and student use case walkthroughs, undertaken in chapter four, provided the user stories specific to each print impairment type and identified accessibility requirements for the user.

In order to determine how to automatically evaluate the outcome of the user tasks against the device and UA accessibility features it was necessary to determine what accessibility metadata could be programmatically detected. Technical specifications and standards were consulted alongside physical tests of devices and manual checks of UAs for this purpose. These determined the availability of accessibility metadata, in the form of API calls, across the entire ecosystem for mobile devices, mobile web browsers and etext formats, specifically the PDF and EPUB3 eformats.

One of the main outcomes of Expert Review Two, was the reduction of the number of components in the accessibility evaluation framework to four, indicated in Figure 8, potentially increasing stakeholder adoption (Vigo and Brajnik, 2011) by cutting down time on each task to be evaluated.

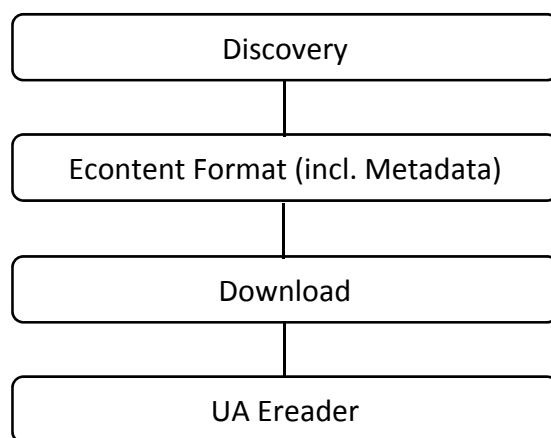


Figure 8: Updated automatic accessibility evaluation framework components.

However, since an accessibility evaluation tool would be undertaking the tests automatically it would require a means to control the verbosity of the reports produced by the tool (Ulltveit-Moe et al., 2008) in human readable form. These updated components provided the basis for two lists of example automatic BW success criteria produced by the instrument.

Firstly, an automatically evaluated list of BW checks for the device, mobile browser and website; and secondly a list of user tasks for discovery and download. The list of automatic BW success criteria were used by the individual experts to review a walkthrough of an HEI library mobile web portal and the prototype of an institute ereader application. This resulted in the exposure of accessibility metadata on the academic publisher's mobile website within an academic or student version of a web application.

As a result of having individual experts testing an example HEI web portal and ereader web application prototype using a representative sample of automatic BW success criteria, generated by the instrument, it was possible to determine how the instrument worked. The success criteria provided the means to write a specification for an automatic accessibility evaluation tool that can be used by designers and developers during the development lifecycle of web applications and a web service.

This automatic accessibility evaluation tool can be further incorporated into four web applications and a web service. It can be used by academics/students as was demonstrated in the Expert Review Two walkthrough and prototype, as well as HEI librarians, academic publishers and academic aggregators. Figure 9, indicates how this is achieved and highlights two outcomes.

Firstly, the automatic accessibility evaluation tool can be used by developers in academic publishing houses and by HEI developers to evaluate the respective web applications developed in-house if required. Secondly, if a third party develops all three web applications and the web service, this could provide a significant advantage over other digital accessibility checkers, particularly for the PDF and EPUB3 formats.

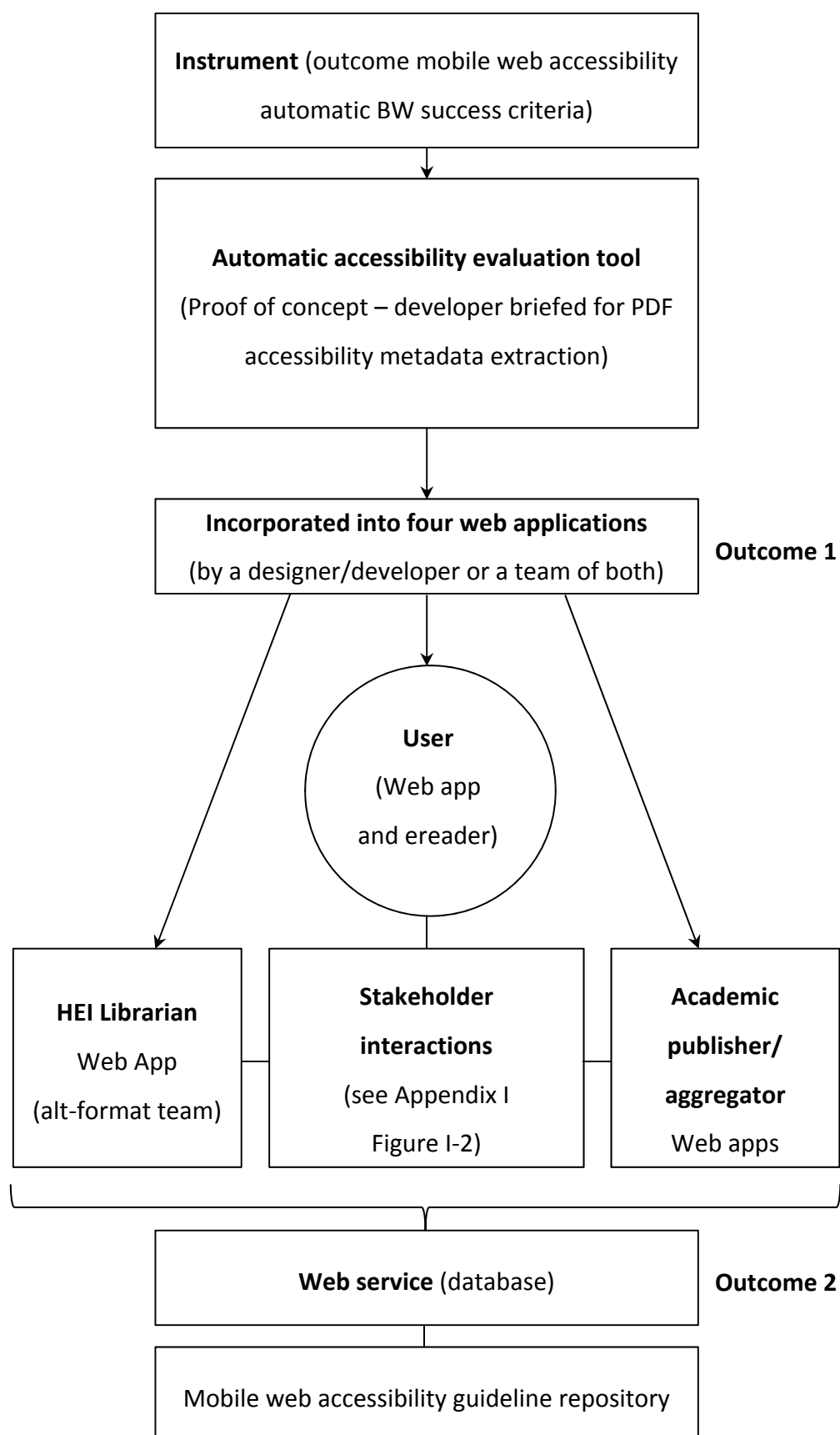


Figure 9: The automatic accessibility evaluation tool incorporated within four web applications for separate stakeholders and a web service.

At the time of writing it appears that there are no similar services available to those involved in the use, provision and support of HE etexts for those with print impairments. The complete specification and wireframe for the web applications and web service follow in chapter eight.

3.4.4 Chapter 7: Instrument results and discussion

The purpose of the evaluation undertaken in chapter seven was not to validate the metric provided when developing the instrument but to finalise the framework and to establish if a prototype could be used. This required an independent means of evaluation through expert review. The instrument also required two remaining components to be analysed in order to complete the integration of the device and UA accessibility support into the five framework components.

Firstly, the availability of the PDF and EPUB3 accessibility metadata, and if these tags were available it would enable them to be programmatically determined by AT. This required a thorough search through the PDF standard BS ISO 3200-1:2008, the basis for the more recent PDF Universal Accessibility standard (PDF/UA). The same was undertaken for the IDPF EPUB 3.0 standard and the ONIX Code list 196 E-publication accessibility details.

Secondly, the mobile device and mobile browser API accessibility support also needed to be determined. Out of the 23 accessibility features, 10 were supported across all three OS platforms and the cross platform mobile browsers, indicating limited support. Once complete the automatic BW success criteria it generated were then used to be able to write a specification and produce a wireframe for a prototype mobile web accessibility evaluation tool. This could then be incorporated into four mobile web applications and a web service. In order to test the instrument and prototype a representative sample of the automatic BW success criteria was selected and then used in a survey for Expert Review Two.

Expert Review Two gathered demographics and expertise data. The comments and responses to Likert scale items from the individual expert participants enabled two key questions to be answered. Firstly, there was a question that determined if the prototype

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and the BW success criteria would work on an HEI library web portal. Secondly, another question established whether the prototype and the BW success criteria would work on a publisher's website. In order to evaluate this, the individual experts had to test a combined prototype and a walkthrough with the predetermined representative sample of BW success criteria. The outcome was that the automatic BW success criteria would work on an HEI library web portal when searching for, finding, downloading, navigating and reading etexts on a mobile device.

This is then followed by a discussion in the chapter of both the tests undertaken and the expert review. This evaluation was important because the key outcome was the alteration of the framework components from five to four. This was based on discovering that the econtent component of the framework could be subsumed into the metadata component. In doing so the component name changed to the econtent format component. This also provided a complete understanding of how the framework is incorporated into the final instrument.

This emphasises the importance of pre-evaluation as stipulated by Patton (1987), in that a full quantitative analysis of the entire instrument and metric could not be undertaken until this ground work had been completed. This research prepares the way forward for this to take place in the future.

3.4.5 Chapter 8: Specification and wireframe

Chapter eight also contributes to how RQ2 is to be answered. The framework, instrument and metric produced as a result of chapters 4 and 6 provided automatic BW success criteria. This was the outcome of an assessment of the evaluation criteria between user tasks and physical and sensory controls that incorporated accessibility requirements for dyslexia. The user tasks involved searching for and finding an etext format referred to as discovery. This format is then downloaded and read using an ereader application. The user is also required to navigate the entire process from discovery to navigating within the etext, such as moving between headings.

The resulting criteria enabled a specification to be written for an accessibility evaluation tool. This was done so that a developer could code the first iteration of the accessibility

evaluation tool that would then be integrated in a web service and four mobile web applications. The entire specification was written to provide an overview for the developer to gain an understanding of how each component would function and the requirements for development. The requirements were separated into three priorities, namely:

1. Essential;
2. Desirable; and
3. Future.

The highest priority within the essential requirements was to provide a proof of concept for extracting PDF accessibility metadata through the use of a web service. The specification not only integrated the framework and instrument it also addressed the issue that academic publishers need to have a means to measure the demand for accessible etexts. In addition to this, the specification also details stakeholder interaction between the academic or student user, the HEI librarian, academic publisher and academic aggregator.

User stories were provided for each stakeholder in the form of a wireframe, these wireframes provide the essential structure of what each stakeholder was required to do when using the respective Web applications. For example, the academic or student user interacts with a web application that enables ereading to take place, this application then automatically updates the HEI library web application and the academic publisher's or academic aggregators web application simultaneously depending on what the academic or student requires. In addition to this, two versions of the academic or student web application were provided, namely the:

1. Lite or free version; and the
2. Institute branded version.

The lite or free version provides access to Open Access materials only for guest users; whereas the institute branded version provides access to both open and restricted access of copyrighted materials through an institute account. Enabling stakeholder interaction reinforced the need for a common language, as identified in Expert Review Two, between

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the academic or student user, HEI librarian, academic publisher and academic aggregator. For example, instead of referring to visual controls, the phrase viewing the screen was used instead. It was for this reason that quick start guides were also included in the wireframes.

In addition to this, it was necessary to include a means for academic or student users to be able to flag an inaccessible etext even if it passes an accessibility evaluation using the relevant web application. In doing so this prevents minimal intervention by the HEI library, academic publisher and academic aggregator, ensuring that remedial action is taken to address the accessibility barrier.

Chapter 4 Development of the framework

This chapter establishes a technology neutral approach to evaluation and demonstrates how RQ1 was to be answered. It develops the five new framework components derived from an adapted model in the background summary (see section 2.5). The reason the framework had to be developed further was because it had to be incorporated into an instrument. RQ1 states: what physical and sensory control categories support automatically evaluating the mobile web accessibility of Higher Education electronic texts for print impairments? The control categories incorporated issues arising for those with dyslexia, a form of cognitive impairment. This chapter establishes four methods for testing in order to answer this research question, namely:

1. Mobile ereader applications by OS and econtent format;
2. Mapping core accessibility settings across mobile devices and UAs;
3. Academic and student use case walkthroughs;
4. Expert evaluation to determine physical and sensory control categories in preparation for Thematic Analysis.

Manual mobile device and UA tests were designed for methods one to three to ensure specific components of the instrument were robust. The physical and sensory control categories enabled the mobile device and UA core accessibility features to be categorised. Determining how the academic and student use case walkthroughs would be undertaken enabled the user tasks relevant to the five new framework components to be established.

4.1 Mobile ereader applications by OS and econtent format

The fourth component of the framework is the ereader as the UA. Mobile ereader applications were selected by analysing the existing availability of ereaders on Google Play, iTunes and the Microsoft Shop that supported the PDF and EPUB3 formats. These were then cross referenced to determine which ereader applications ran on all the mainstream mobile operating systems, namely Android, iOS and Windows.

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This list of mobile ereader applications was also used in Expert Review Two as an incentive for participants to take part in the survey. This was because it would save HEI librarians, academic publishers and academic aggregators a great deal of time analysing each ereader for format and OS accessibility support. For example, the Lektz and VoiceDream Reader, at the time of writing, did not support the Windows Phone OS but each supported both the PDF and EPUB3 formats.

References to accessibility either on the developer's website or the vendor's app store, such as Google Play, were recorded. It was then realised that this information reflected marketing information rather than actual UA accessibility support and was not taken further. Alongside this the mobile ereader applications were downloaded, where possible onto an Android device for pilot tests to determine suitability for testing during the academic and student use case walkthroughs.

For example, the Bureau van Dijk Reader (Publizard) required an institute account and prevented further testing. There were other reasons why mobile ereader applications were not shortlisted. The Nook Reader was only available in the US and certain ereaders were not reliable crashing regularly. The Infinity Reader is an example of a mobile ereader application that provides equivalent print page numbering, demonstrating that if the appropriate accessibility metadata is provided this can be presented in human readable form. It was also only available for the Android OS and supported the EPUB3 format and was not included in the final shortlist. Using this process a shortlist of 10 mobile ereader applications was determined.

4.2 Mapping core accessibility settings across mobile devices and user agents

It was realised that by mapping mobile web accessibility features across the device and UA ecosystem, core accessibility settings could be determined. For example, Talkback is the in built screen reader for the Android platform, identified during the use case walkthroughs. The iOS and Windows mobile platforms also have their respective in built screen readers: VoiceOver for iOS, and Narrator for the Windows OS, albeit under different manufacturer device setting categories. Figure 10 demonstrates this mapping

between an Android Nexus 5 box (a), iPhone 6 box (b) and the Windows Phone 8.1 box (c).

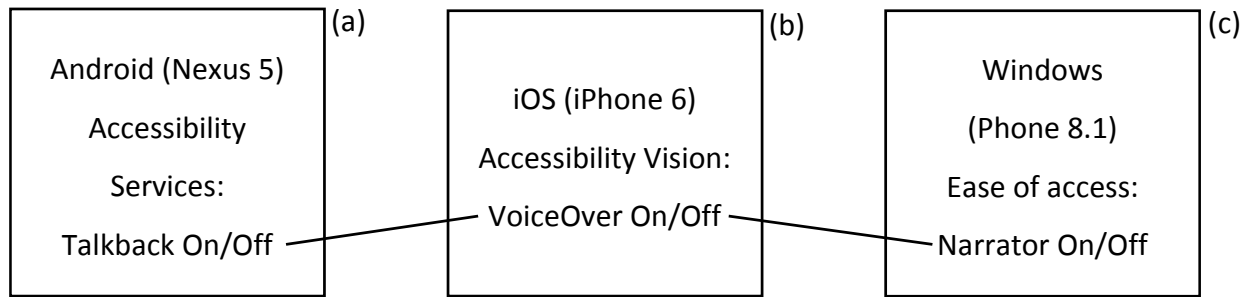


Figure 10: Example core device accessibility settings - mapping between screen readers.

Therefore, one of the core accessibility settings that needs to be evaluated against the user tasks within the HEI library mobile web context for those with print impairments is the use of the devices screen reader.

If in the future, a new mobile OS is introduced to the mainstream mobile device marketplace core accessibility setting for screen reader use would need to be evaluated on that device. In addition to this, with the plethora of mobile devices and UAs, variations between manufactures and developers categorisation of device and UA settings, and constant updates within this ecosystem a technology agnostic approach is critical. This would be inline with the WCAG 2.1 premise of a technology neutral and objective means of evaluation (W3C, 2018). The other aspect of this method was that it would also identify mobile device platforms, ereader applications, online readers and mobile browsers that do not offer accessibility support for those with print impairments such as switch access control.

Using the same approach, core device accessibility settings can be determined for visual impairments, such as the use of colour inversion or high contrast, magnification or zoom, and font or text size. In terms of dyslexia global features exist on the mobile device that enable Text to Speech (TTS) settings to be altered. If the user has a mobility impairment the core accessibility setting to be evaluated would be switch access or switch control. In each instance the terminology is specified by the mobile device manufacturer. One further aspect that also required evaluation was whether accessibility settings enabled the user to alter menu settings on the device to improve the readability of device

Chapter 4: Development of the framework

navigation. For example, on the Android device the setting 'Large Text' increases the font size of navigation menus; whereas 'High Contrast' on the Windows Phone alters the device menu settings to have for example yellow text on a black background. Including this as part of the evaluation process also identified whether the menu settings text and background colour could be customised for those with dyslexia. For example, altering a device menu so that it has a pale blue background with dark blue text.

Determining the core accessibility settings also identified the difference between parent and child accessibility settings. For example, on the Android device 'Speech Rate' is a child setting of the parent setting 'Talkback'. Speech rate in this context can only alter the speech rate of the screen reader; whereas speech rate for TTS would only alter the speech rate for TTS.

In discovering this, it reduces the number of accessibility settings that need to be evaluated against the user tasks in the HEI library mobile web context. Being able to alter the speech rate of the screen reader is important for a blind user, but if the HEI web portal is not accessible to the screen reader there is no need to evaluate this setting. It was also realised that evaluating speech rate would be an objective means to measure usability of the mobile screen reader rather than the accessibility of the screen reader itself.

The analysis of device and UA accessibility settings would also require determining the relevance to HEI ereading and any potential conflicts there maybe between the device accessibility settings and the UAs. For example, if TTS in the UA is allowed to operate at the same time the OS screen reader reads aloud econtent there is a conflict. Another aspect that required evaluation would be global controls that allow the user to customise the accessibility settings of the entire device in one place and whether these powerful features can be recognised by ereader applications.

The support for the PDF and EPUB3 formats was also ascertained for each ereader application and whether accessibility metadata for these formats was made available in human readable form within the application. The availability of accessibility settings was also then mapped between the mobile ereader applications. In doing so this provided a core set of mainstream ereader applications that gave accessibility a priority. In total 10

were analysed, Figure 11 gives an example of the mapping that took place between three of the mobile ereader applications for text size using the EPUB3 format. These included Adobe Digital Editions box (d), Ideal Group Reader box (e) and VoiceDream box (f).

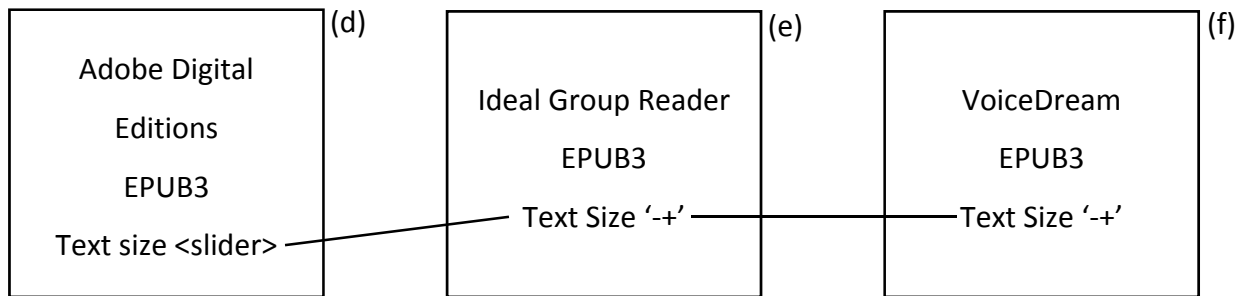


Figure 11: Example core accessibility settings - mapped across mobile ereader applications.

Since the Chrome, Firefox and Opera mobile browsers operate across all three mainstream mobile devices these were selected for analysis. Figure 12 indicates an example mapping between the mobile browsers Chrome box (g), Firefox box (h) and Opera box (i) for the accessibility setting force enable page zoom. This setting overrides a website displayed on the mobile device that has disabled zoom functionality on the website.

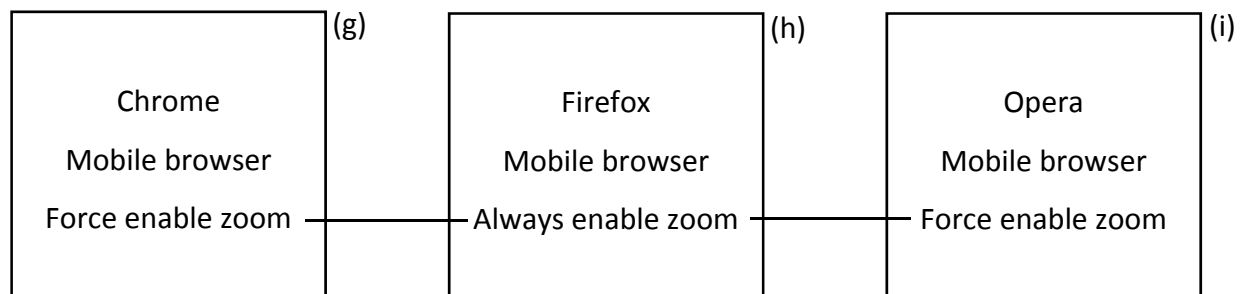


Figure 12: Example core accessibility settings - mapped across mobile browsers.

Although three online readers, including the Firefox PDF cloud viewer were analysed, only two examples are indicated in Figure 13, for Play/Pause an accessibility setting relating to playing or pausing TTS. This was for the Radium online reader box (j) and the beta version of the Bureau Van Dijk reader box (k). The reason for this was that the Firefox PDF Cloud viewer did not operate when undertaking the analysis and the Google PDF viewer was used instead. The Google PDF viewer provided no accessibility settings.

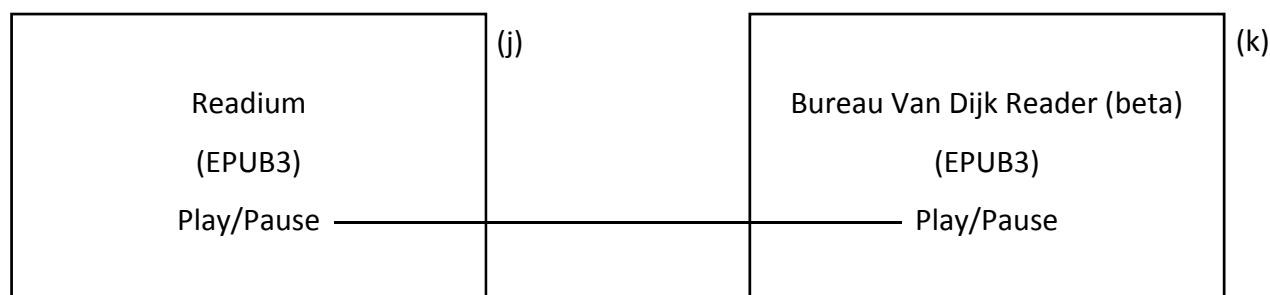


Figure 13: Example core accessibility settings - mapped across online ereaders.

4.3 Academic and student use case walkthroughs

In total 10 accessibility use case walkthroughs were undertaken on a smartphone device in order to determine what user tasks were actually required by print impaired academics/students. Both academic and student users were treated as a single entity since the user tasks required during the process of searching for, finding, downloading, navigating and reading an etext on a smartphone were the same. Different features were assessed for accessibility support based on print impairments. Three main types of accessibility settings were analysed across this ecosystem and related to:

1. Visual impairments (including blindness);
2. Dyslexia, a form of cognitive impairment; and
3. Physical difficulties, such as motor impairments.

The Android use case walkthroughs identified features that met the accessibility requirements of those with print impairments through device, ereader applications (including online readers, such as Radium) and mobile browser accessibility settings. The inbuilt device screen reader Talkback and the Firefox Mobile Browser version 50.0.2 were used. In addition to this the Firefox PDF Cloud Viewer and a Bluetooth 3.0 keyboard were also used. Five related to the use of device accessibility settings by blind and visually impaired users. Four related to those settings used by dyslexic users and one for physical difficulties where switch control was required. The number of steps were counted for the process for each print impairment use case.

The following provides an example breakdown of what was done for an academic and student use case walkthrough for an HEI library web portal, including the download and

subsequent reading of an etext for those with print impairments. The web portal referred to here was the University of Southampton SUSSED hand-off to the University Library portal so that an ACM publication could be downloaded and read on a mobile device. The following three main points were based on notes taken during the physical device testing for each print impairment.

1. Blind and visual impairments:

1.1. Screen reading:

The PDF Cloud Viewer and a Bluetooth 3.0 keyboard were used. The Bluetooth keyboard was setup to allow arrow and tab keys to move focus. The PDF Cloud Viewer did not work and the Google Drive PDF viewer was used instead. This only allowed the PDF to be viewed and no other functionality was available. When Talkback was activated the Global and Context Menus were accessed with swipe gestures. Swipe Down and Right brings up the Global Context Menu. Swipe Up and Right brings up the Local Context Menu and were dependent upon what was selected.

1.2. High contrast – specifically colour inversion on the Android device:

The Google Drive PDF viewer and a Bluetooth 3.0 keyboard were used. The accessibility setting colour inversion was selected and activated.

1.3. Colour correction for colour blindness/deficiency:

The Google Drive PDF viewer and a Bluetooth 3.0 keyboard were used. The accessibility setting colour correction was selected and activated. This was set to deuteranomaly (red-green).

1.4. Magnification gestures:

The Google Drive PDF viewer and a Bluetooth 3.0 keyboard were used. The accessibility setting Magnification gestures was used. Since the SUSSED website and ACM website are non-responsive, swipe gestures were required to zoom in and pinch gestures to zoom out. By triple tapping on the home screen or the device menus the magnification works but requires three fingers to scroll. Also in the mobile browser settings 'Always enable zoom' was selected and activated.

1.5. Increase font size:

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The Google Drive PDF viewer and a Bluetooth 3.0 keyboard were used. The device accessibility setting large text was selected and activated for device menus. Whereas Adobe Acrobat reader reflow was used to alter font size in the PDF by using pinch and zoom gestures.

2. Dyslexia – a form of cognitive impairment, including visual stress:

2.1. TTS:

The Google Drive PDF viewer and a Bluetooth 3.0 keyboard were used. The Graham voice installed by default into Voice Dream was used, with the speech rate set to 180 words per minute. TTS was only used as and when required. The two most distinct areas required the user to read the pre download abstract and the etext itself.

2.2. Margin, line and character spacing – this includes visual stress:

The features available within VoiceDream to alter margin, line and character spacing for the EPUB3 format were used.

2.3. Read along:

Media overlays were used, this setting provided the user with the option of reading along with a moveable highlight bar as the text was read aloud through the TTS engine. The volume could be turned down if no TTS was required.

2.4. Alter themes - this includes altering the style of available fonts:

Font Colour and Background colour can only be adjusted in EPUB3 because Adobes proprietary software was required to change background colour and text colour in Adobe Acrobat Standard for Desktop. Custom theme colours for spoken word, spoken line colour and highlight colour can be altered in VoiceDream. The Android version of VoiceDream was temperamental and crashed. These were reported to VoiceDream. In addition to the Light/Dark themes referred to in the Visual Stress section there is also the Custom Theme option. According to Web2Access adjusting text colour, background colour and text type (font style) can be essential to those with visual processing difficulties (Web2Access, 2018). The PDF ecosystem prevents the altering of custom text colour and background colour. The only options are night mode with white text on a black background. Or in VoiceDream these options are Dark, Light or Custom. 'Dark' is white text on

a black background. 'Light' is the reverse of this. The custom option is dealt with by using themes.

3. Physical difficulties.

3.1. Switch access control, using scan:

The accessibility settings for 'Switch Access On' with 'Scanning Method Row-Column (keyboard only)' was selected and activated. 'Scanning highlight colour' was set to red with highlight line style set to thin solid line. Auto Scan was disabled. The default assigned keys for scanning are Space for Select, and a period indicated thus '.' for next and ',' for previous. This automatically starts scanning when deselected.

In each use case the five new framework components were tested, namely:

1. Discovery;
2. Metadata;
3. The econtent format, namely the PDF and EPUB3;
4. The ereader, as a UA; and finally
5. The econtent.

The ereader component, referred to here, suggests a single connection to the device, however, all five components take place through the device and why the device had to be integrated into the framework. In order to fully understand how this would be achieved further analysis was required. This was also in line with the request made by Kaur and Dani that platform and device characteristics need to be considered for the adequacy of mobile web accessibility evaluation tools (Kaur and Dani, 2017). It also contributes to addressing the now dated Mobile Web Best Practice (MWBP) guidelines as suggested by Kaur and Dani (Kaur and Dani, 2017).

In doing so this identified the number of potential barriers that could be encountered by users with print impairments specific to the user tasks. It also identified the available features on the Android device relating to accessibility settings. This formed the first stage of developing sets of automatic BW success criteria. Another significant aspect of the walkthroughs was actual device testing against the specified user tasks.

Chapter 4: Development of the framework

Since the walkthroughs were undertaken on a single platform, namely the Android device, it was therefore essential to incorporate other mainstream device operating systems. In this case the iOS and Windows platforms were brought into the framework. Device availability and the amount of time it required to evaluate a device was a significant issue, and a method had to be devised that took the findings of the Android use case walkthroughs and then apply them to the other mainstream platforms.

4.4 Expert Review One method

20 expert participants were approached during a break while attending a face to face meeting on the 14th January 2016 at the University of Southampton, relating to the use and development of alt-formats. The attendees were from non-governmental organisations and other HE institutes in the UK, the majority of whom were unknown to the researcher. No external email lists were used by the researcher in order to contact the experts. The meeting was pre-planned by an external expert ensuring that the attendees, included HEI librarians, accessibility specialists and consultants from the alt-format domain. The researcher was invited as an attendee to present the survey and was not assisted or had collaboration with the organisers.

Only the expert participants who read the distributed participant information and expressed informed verbal consent were accepted as participants and were allowed to undertake the survey. In the participant information the experts were instructed not to confer with other colleagues while answering the survey but would be free to do so after the survey was completed. In addition to this the participants were informed about the survey aims in the following way:

‘What is the research about? This is a doctoral research survey which aims to begin to establish the functional categories for device, in-application and, if available, in-browser accessibility settings on mobile platforms and the principles behind the categories.’

The expert participants were informed that taking part in the study would add to current knowledge about Mobile Web Accessibility in Higher Education.

The informed verbal consent took the following form:

Verbal Consent Wording: Post presentation and following the distribution of participant information, the wording for verbal consent will be as follows:

‘Do you give your informed consent to take part in this survey?’

12 expert participants (n=12), 5 male and 7 female, agreed to take part in the review. The ethics application for Expert Review One was ERGO/FPSE/18699. The stimuli given to the experts included a 2-3 minute presentation and a semi structured hard copy questionnaire that provided a further comments section at the end of the survey. The questionnaire took approximately 15-20 minutes for the individual expert participants to fill out. The presentation material given to the experts referred to manufacturer mobile categories, see Figure 14, and functional mobile categories, see Figure 15, the framework and how it incorporates the device, see Figure 16.



Figure 14: Manufacturer mobile categories.



Figure 15: Functional mobile categories.

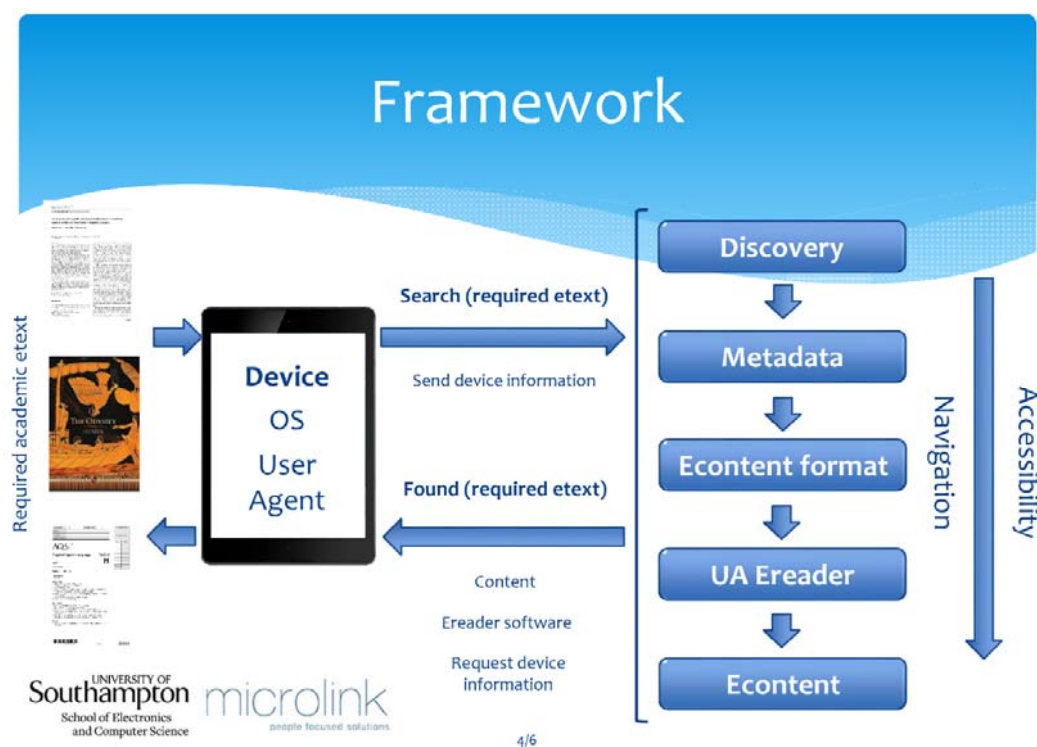


Figure 16: The framework integrating the device.

The presentation also briefly referred to the potential stakeholders that could benefit that could benefit from the mobile web accessibility evaluation tool namely the academic or student users, HEI librarians, academic publishers and academic aggregators. The individual expert participants were then allowed to ask questions after the presentation, particularly if clarification was required.

The questionnaire required participants to answer three sets of questions that related to:

1. Demographics and expertise;
2. The physical and sensory control categories for accessibility settings that relate to HE texts for those with print impairments; and
3. The principles behind the control categories.

Both demographic and expertise data was collected to provide a population sample and to determine what constituted an expert. The demographic questions related to gender and age range in the following form:

What is your gender? M ☐ F ☐ Other ☐ (Please specify: _____)

Prefer not to say ☐

What is your age range?

18-29 ☐ 30-49 ☐ 50-64 ☐ 65+ ☐ Prefer not to say ☐

The expertise of the participants was ascertained by requiring participants to answer the following closed ended questions.

Subjective Knowledge Rating:

On a scale of 1 to 5 what is the level of your domain knowledge or expertise?

1 = lowest and 5 = highest: 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

Worked as a consultant/specialist/librarian for:

Less than two years ☐ 2-5 years ☐ 6-10 years ☐ 11-15 years ☐ 16+ years ☐

Tested more than 10 web sites for accessibility? Yes ☐ No ☐

Chapter 4: Development of the framework

Tested mobile applications/browsers for accessibility? Yes ☐ No ☐

Tested mobile devices for accessibility? Yes ☐ No ☐

Do you use an ereader for reading academic etexts? Yes ☐ No ☐

If a participant indicated that they had worked for less than two years as an expert the results of their questionnaire were not analysed. The questions relating to expertise included a Subjective Knowledge (SK) rating, the range in number of years worked as a consultant/specialist, and actual experience testing web sites, UAs, and mobile devices for accessibility. This was inline with the recommendation by Brajnik *et al* that more useful information is gleaned by determining the actual expertise of participants enabling the results to have greater validity (Brajnik et al., 2011).

In addition to this, the individual expert participants were asked if they had used an ereader for reading academic etexts. The reason for this was to determine experience with using ereaders for reading HE etexts. The experts would therefore be more likely to understand the potential barriers faced by academics or students.

The expert participants were also instructed in the questionnaire to comment in the answers they provided if they felt that the survey would not provide relevant data. In addition to this the researcher told the participants that they would be available throughout and to ask questions at anytime if required.

Two key open ended questions were also asked in the questionnaires as part of the survey, namely:

1. Based on human cognition and the human senses what functional categories for device, application and browser accessibility settings should there be on a smart-phone or tablet?
2. What principles should govern the functional categories?

These questions allowed individual expert opinions to be gathered for Thematic Analysis post survey. Six phases of thematic analysis were undertaken as specified by Braun and Clarke, namely:

1. Familiarisation of the collected data;
2. Coding the qualitative data;
3. Searching for themes;
4. Reviewing themes;
5. Defining and naming themes; and
6. Producing a final report (Braun and Clarke, 2006).

NVIVO was used to determine a coverage percentage indicating how much the source content was coded at a specific theme. In addition to this, the expert participants anonymised SK rating and expertise by year range added to the validity of the theme identified. In doing so, this may help to address reliability because only one coder was available to code the expert review qualitative data. Miles and Huberman recommend that to test the reliability of Thematic Analysis a minimum of two coders are required (Miles and Huberman, 1994).

4.5 Chapter Summary

The five new framework components derived from an adapted model, as previously discussed in the background summary (see section 2.5), were developed in three ways. Firstly, a method had to be established in order to analyse the mobile ereader applications by OS and econtent format. This was achieved by shortlisting ereader applications based on their support for both the PDF and EPUB3 formats. In tandem with this the list was reduced still further by determining which ereader applications supported all three mainstream mobile operating systems, namely Android, iOS and Windows at the time of writing.

Secondly, an additional method had to be developed that analysed the core accessibility settings across mobile devices and UAs. This was achieved by mapping these core accessibility settings. In doing so this produced a technology neutral means of evaluation between mobile devices, mobile web browsers including online ereaders and mobile ereader applications.

Thirdly, a method was devised for undertaking academic and student use case walkthroughs. This was achieved by analysing different accessibility features available to

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the mobile devices, mobile web browsers, online ereaders, and mobile ereader applications against the accessibility requirements of those with print impairments. Manual testing was undertaken for each of the mobile device and UA accessibility settings.

Finally, the method undertaken for Expert Review One required the use of a questionnaire survey presented to alt-format experts. This was to determine the physical and sensory control categories for the mobile device and UAs. The survey enabled the individual experts to make comments that could then undergo Thematic Analysis. This was taken forward by undertaking the tests in preparation for incorporating the findings into an instrument. The instrument enables the physical and sensory control categories, with sub-divided mobile device and UA accessibility settings, to be analysed against the user tasks specific to the five new framework components. This prepared the way for tests specific to discovery, humanly readable accessibility metadata of the PDF and EPUB3 formats, the download to the mobile device and UA, navigating and reading HE etexts.

Chapter 5 Framework results and discussion

The framework results are provided in this chapter for the testing stages that then lead into the results for Expert Review One, concluding with a summary for the review. The primary means of analysis for Expert Review One was through Thematic Analysis as suggested by Braun and Clarke (2006). The results are then discussed and include the limitations for the review. The chapter then concludes with an overall summary of the findings.

5.1 Results

24 core mainstream features were identified when mapping the core accessibility settings across mobile devices and UAs to the five framework components. This process integrated device characteristics into the framework and helped to address the now outdated Mobile Web Best Practice (MWBP 1.0.)

Three of the features analysed related to Wifi, Virtual Private Network (VPN) and Bluetooth and were included because these settings need to be setup by the user on the device, but were not carried through into the instrument. Wifi is required to access the HEI library web portal on a mobile device via Eduroam on campus. VPN is necessary to access the HEI portal via 4G or 5G off campus. Bluetooth is typically required for connectivity to an external Bluetooth keyboard/switch when using a mobile device and to a refreshable braille display. In terms of mapping to the framework both Wifi and VPN relate to Discovery whereas Bluetooth relates to the device.

The four core accessibility settings that related to captioning when using multimedia were not carried through into the instrument. This was because multimedia was established as being beyond the scope of this thesis. However, this does not mean this should not be investigated in future research and could be included in the instrument at a later stage. 7 core accessibility settings were not available on the Windows 8.1 phone, at the time the mappings were undertaken. These included:

1. Switch access control (parent setting) and six child settings;

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2. Global/local context/rotor feature (parent setting) and four child settings;
3. Use pitch change;
4. Braille (connectivity);
5. Single tap selection;
6. Gestures – these were limited;
7. Colour correction by downloading third party applications.

3 adult features had 12 child settings in total, namely:

1. Screen reader/Text to Speech (TTS):
 - 1.1. Speech rate;
 - 1.2. Use pitch.
2. Switch Access Control:
 - 2.1. Scanning highlight style;
 - 2.2. Auto-scan;
 - 2.3. Step Scanning;
 - 2.4. Option Scanning;
 - 2.5. Auto-scan time;
 - 2.6. Touch and Hold Delay.
3. Global or Local Context/Rotor Tool:
 - 3.1. Line Granularity;
 - 3.2. Word Granularity;
 - 3.3. Character Granularity;
 - 3.4. Links menu.

The core accessibility features across the three mainstream devices for Android, iOS and Windows mobile devices were divided into four functional device control categories and mapped to the five new framework components. In doing so this produced a technology neutral approach for the device accessibility features whether they were adaptive or adaptable. It was also discovered that conflicts could occur between device and ereader settings and have been referred to as conflict warnings. Conflict warnings occurs when an OS setting conflicts with the mobile ereader application setting. For example, if the user sets the screen brightness using the OS settings a screen brightness setting within the

mobile ereader application would be clearly problematic. This is where the mobile ereader application would need to be able to recognise mobile OS features such as adaptive brightness, where the device automatically adjusts the screen brightness based on ambient light levels. Focus transitions occur when moving focus from the device OS menus to the mobile ereader application menus. This resulted in 24 technology neutral core accessibility device features, 9 conflict warnings and 2 focus transitions, see Table 4. This is then followed by the relevance to HEI ereading for specific accessibility features. Table 5 is a summarised version, please refer to Appendix E for the detailed breakdown.

Table 5: Technology neutral core accessibility features against functional device control categories mapped to five new framework components. Continued on next page.

Functional device control category	Technology neutral core accessibility mobile device features (adaptive/adaptable)	Mapping to five new framework components and device
Vision	1. Accessibility shortcut	Device
	2. Auto capitalisation (alt access)	Ereader
	3. Brightness	Device and ereader (conflict warning)
	4. Colour correction	Device and ereader (conflict warning)
	5. High Contrast/Colour inversion	Device and ereader (conflict warning)
	6. Font size	Ereader
	7. Language & Region (text)	Device and ereader (conflict warning)
	8. Large Text	Device
	9. Magnification/Zoom	Device and ereader (conflict warning)
	10. Text correction (alt access)	Discovery and ereader

Table 5 continued.		
Functional device control category	Technology neutral core accessibility mobile device features (adaptive/adaptable)	Mapping to five new framework components and device
Touch	11. Braille	Device and ereader (focus transition)
	12. Manage Gestures	Device
	13. Onscreen keyboard	Device
	14. Single tap selection	Device and ereader (conflict warning)
	15. Switch Access Control	Device
	16. Vibration feedback (haptic)	Device
	17. Rotate screen	Device and ereader (conflict warning)
	18. Storage and USB	Econtent format download
	19. System & ereader updates	Device and ereader (conflict warning)
Audio	20. Context menu/rotor tool	Device (focus transition to ereader)
	21. English (United Kingdom) - TTS	Device and ereader (conflict warning)
	22. Screen reader	Device
	23. Speak usage hints (alt access)	Device and ereader (conflict warning)
Voice	24. Built in voice recognition	Discovery and device

The following reflects the relevance to HEI ereading for specific accessibility features:

Vision:

- Accessibility shortcut: this increases the speed and reduces the number of steps required for the print impaired reader to go from Discovery through the OS to the econtent.

- Auto capitalisation (alt access): is required when annotating an etext. This increases the speed of input.
- Brightness: is required to view the screen in bright sunlight or to reduce screen glare when reading at night.
- Colour correction: enables the user to alter on screen colours to accommodate colour blindness and would be required in the OS and UA menus and the econtent.
- Colour inversion: enables navigation menus to have a black background but there is a potential UA conflict.
- Font size: is required to help visually impaired readers to customise etext size when reading.
- Language & Region (text): is required so the user can set the language of their preference and to then display on screen text in that chosen language.
- Large Text: is required to help visually impaired users to read OS setting menus.
- Magnification/Zoom: is required when viewing a PDF that does not allow reflow or a website that does not allow text size or image size alterations. This can cause horizontal scrolling.
- Text correction (alt access): is required when annotating or searching for an etext and increases the speed of input.

Touch:

- Braille: this setting is required to access a Bluetooth Braille Display. Braille users do not tend to use refreshable Braille Displays to read large amounts of text, it is used for correcting text or for specific navigation.
- Manage Gestures: managing custom gestures or having access to a reminder list of available gestures is essential, particularly for navigation in the OS and the UA.
- Onscreen keyboard: enables the user to change the keyboard language and would be required for searching and annotations. In some instances on screen keyboards have voice recognition features and require this feature to be activated.
- Single tap selection: is required in order to speed up navigation and to get to the econtent faster.

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- Switch Access Control: is required for navigation within the OS and the UA and between the two for users with motor impairments.
- Vibration feedback (haptic): haptic feedback helps users in the OS menus and UA reading menus to be aware of an activated item.

Special cases:

- Rotate screen: reading in landscape mode is better at sentence level and reading in portrait mode is better for paragraphs.
- Storage and USB: management of device storage and cloud storage is required when downloading etexts.
- System and ereader updates: are required for the app to request OS permissions and is useful to the user if required.

Audio:

- Context menu/rotor tool: enables the user global command of accessibility settings and is useful for ereading but only if the UA is able to recognise this is available on the device.
- English (United Kingdom): is helpful with localisation and provides speech output in the required language, if it is available for the device.
- Screen reader: is required specifically for the user to navigate from the OS to the ereader. There is a potential conflict between the OS and the UA if TTS is allowed to operate at the same time the OS screen reader is allowed to read aloud.
- Speak usage hints (alt access): is required for inexperienced users requiring further assistance for accessibility when in the OS and the UA.

Voice:

- Built in voice recognition: voice recognition aids searching etexts and the use of the onscreen keyboard when creating annotations. It is not recommended for large amounts of text because of battery consumption.

Once the core device accessibility settings were analysed, and their relevance to reading etexts in HE established, it was then necessary to analyse which mobile ereader

applications supported the PDF and EPUB3 formats. This was also mapped alongside the operating systems that were supported. The applications were excluded if they were not supported on all three mobile operating systems and was inline with a technology neutral approach. There were two exceptions, the Lektz and VoiceDream Reader applications. The Lektz application was included because the Dyslektz ereader required a Lektz account ID. The VoiceDream reader was included because of its reputation as an application that prioritised accessibility. Table 6 indicates the 16 ereader applications that were analysed.

Table 6: Mobile ereader applications supporting the PDF and/or EPUB3 format.

Mobile ereader application	PDF	EPUB3	Android	iOS	Windows Phone
1. Adobe Acrobat Reader	✓	✗	✓	✓	✓
2. Adobe Digital Editions	✓	✓	✓	✓	✓
3. Amazon Kindle	✓	✗	✓	✓	✓
4. Blio ebook reader	✓	✓	✓	✓	✓
5. Bluefire Reader	✓	✓	✓	✓	✓
6. Bureau van Dijk Reader (Publizard)	✓	✓	✓	✓	✓
7. Dyslektz (requires Lektz ID)	✓	✓	✓	✓	✓
8. Ebscohost Mobile	✓	✓	✓	✓	✓
9. Gitden Reader and PDF Plugin	✓	✓	✓	✓	✓
10. IDEAL Group Reader	✗	✓	✓	✓	✓
11. Lektz	✓	✓	✓	✓	✗
12. Kobo (Rakuten)	✗	✓	✓	✓	✓
13. Nook (available only in the US)	✓	✓	✓	✓	✓
14. Overdrive Media Console	✗	✓	✓	✓	✓
15. VI Reader – Sensus	✗	✓	✓	✓	✓
16. Voice Dream Reader	✓	✓	✓	✓	✗
Total	12	14	16	16	14

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Based on this the following 10 native applications were shortlisted and were used when mapping core accessibility settings across UAs:

1. Adobe acrobat reader;
2. Adobe Digital Editions;
3. Blio;
4. Bluefire Reader;
5. Gitden;
6. Ideal Group Reader;
7. Kobo;
8. Lektz;
9. VI Reader; and
10. Voice Dream.

Undertaking this analysis indicated that not only the PDF format but that the EPUB3 format would also need to be included when undertaking automatic accessibility evaluations. The core accessibility settings across the above 10 ereader applications were then mapped.

Table 6 provides a summarised version. See Appendix F for a detailed breakdown of all the features available to the 10 shortlisted ereader applications. For each ereader application the number of features, for example relating to reading, were counted and a total score was allocated.

The VoiceDream reader had the highest number of accessibility features out of all 10 shortlisted ereader applications. VoiceDream scored 51 whereas the joint next highest scoring of 38 was for the Bluefire Reader and the Ideal Group Reader. This finding corroborated the VoiceDream reader reputation.

Table 7: Mapping core accessibility settings across 10 ereaders. Continued on next page.

No.	Feature/ Framework	Adobe Acrobat Reader	Adobe Digital Editions	Blio	Bluefire Reader	Gitden	Ideal Group Reader	Kobo	Lektz	VI Reader	Voice Dream	Total
1	About	0	1	1	1	0	0	1	0	0	1	5
2	Account	3	3	3	3	3	1	3	3	1	2	25
3	Annotation	3	1	0	1	4	9	0	1	0	4	23
4	Bookmarking	1	1	1	1	1	3	2	1	1	1	13
5	Discovery	0	0	3	2	2	1	1	5	0	1	15
6	Metadata	0	0	0	1	0	0	0	0	0	0	1
7	Format Support	1	4	1	2	2	1	3	2	0	2	18
8	Help Documentation	1	0	2	1	2	2	6	0	1	2	17
9	Printing	1	0	0	0	0	0	0	0	0	0	1
10	Library In-app (bookshelf)	1	1	3	3	2	2	2	1	0	5	20
11	Reading	7	9	11	18	17	17	11	11	9	27	137
12	Search etext	1	1	1	1	1	0	1	1	0	1	8
13	Scanning and OCR	1	0	0	0	0	0	0	0	0	0	1

Table 7 continued.												
No.	Feature/ Framework	Adobe Acrobat Reader	Adobe Digital Editions	Blio	Bluefire Reader	Gitden	Ideal Group Reader	Kobo	Lektz	VI Reader	Voice Dream	Total
14	Social media	2	0	0	0	0	0	1	1	0	0	4
15	Storage	4	0	1	1	1	1	2	1	1	1	13
16	Navigation	2	3	2	3	2	1	2	2	1	2	20
17	User behaviour	2	0	0	0	0	0	1	1	0	2	6
Total		30	24	29	38	37	38	36	30	14	51	327

The Bluefire Reader ingests publisher's accessibility metadata, only in so far as it allows the user to determine if a PDF can be printed, that text can be copied and pasted, and if it can be viewed on any device. This accessibility metadata was presented in human readable form within the application. Unfortunately, however, the Bluefire reader application did not provide continuous reading by TTS. It also revealed that the VoiceDream Reader provided the greatest accessibility support and was the reason why it was used in the academic and student use case walkthroughs.

Seven out of the 10 ereader applications supported Non DRM protected PDFs; whereas eight out of ten supported the Non DRM protected EPUB3 format. Two of the applications supported DRM protected PDFs, namely Adobe Digital Editions (ADE) and KOBO. Only one application supported DRM protected EPUB3, this was ADE. However, out of the 133 core features mapped across the 10 ereader applications, ADE only supported 24. The core accessibility settings were supported by more than 50% of the

ereader applications for 23 features, as indicated in Table 8. The features for registering, signing in and signing out relate to authentication within the ereader application. Three of the applications sign the user out automatically on exiting the ereader. However, authentication also enables a user to gain access to free etexts within catalogues such as the Open Publication Distribution System (OPDS).

Table 8: The settings supported by over half of the ten ereader applications.

Continued on next page.

No	Feature	Number of applications supporting the feature
1	About	5
2	Register	8
3	Sign In	10
4	Sign out	7 (3 signed out automatically).
5	Bookmarks	10
6	OPDS Catalogue/Free ebooks	5
7	Non DRM protected PDF	7
8	Non DRM protected EPUB3	8
9	Help	8
10	Bookshelf	9
11	Search bookshelf	5
12	Day (reading mode)	6
13	Night (reading mode)	7
14	Text preview	6
15	Font size EPUB3	9
16	Font style (EPUB3)	6
17	Line spacing (EPUB3)	6

Table 8 continued.		
No	Feature	Number of applications supporting the feature
18	Background colour (EPUB3)	6
19	Brightness slider	6
20	Search book	8
21	Import book	8
22	Table of contents (TOC)	10
23	Progress slider	8

Although font size is indicated in Table 8 as being supported by those applications using the EPUB3 format, Adobe Acrobat Reader also enables the user to alter font size through gestures when in reflow mode. One feature, the brightness slider, is useful when reading in direct sunlight, but can cause a conflict between the ereader application setting for brightness and the device setting for brightness.

Table 9 indicates the mapping between the three cross platform mobile browsers, Chrome, Firefox and Opera, and revealed that the 'About' feature, 'Sign In' and 'Page Zoom' were supported across all three platforms (see Appendix F for the detailed breakdown). The 'About' feature was included because this provides the user with details about the version number of the mobile browser. The Firefox mobile browser had the highest number of accessibility features. Two out of the three browsers supported three features:

1. Frequently asked questions (FAQs);
2. Feedback; and
3. Text size using incremental settings or a slider tool.

Table 9: Results for mapping core accessibility settings for cross platform mobile browsers.

No.	Feature	Chrome	Firefox	Opera	Total
1	About	1	1	1	3
2	Account	1	1	1	3
3	Help	0	2	3	5
4	Text Size	1	1	0	2
5	Force enable zoom/Always enable zoom	1	1	1	3
6	Voice (within the address bar)	0	1	0	1
7	Gesture & sonar (sonar is navigation by voice within the mobile browser)	0	0	0	0
Total		4	7	6	17

Out of the three online ereaders, indicated in Table 10 where core accessibility settings were mapped (see Appendix F for the detailed breakdown), only two online readers provided an 'About' page, namely Radium and the Firefox PDF Cloud Viewer add on. Radium and the Bureau van Dijk online beta version ereader provided additional keyboard shortcuts that can be accessed via an external Bluetooth keyboard on a smartphone device; the following 11 features were mapped:

1. Table of contents (TOC);
2. Previous page;
3. Next page;
4. Play/Pause;
5. Previous audio phrase;
6. Next audio phrase;
7. Increase audio volume;
8. Decrease audio volume;

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9. Increase audio playback rate;
10. Decrease audio playback rate;
11. Enter/exit full screen.

Table 10: Results for mapping core accessibility settings for online readers.

No.	Feature	Radium (EPUB3 Firefox)	Bureau Van Dijk (EPUB3 – Firefox)	Firefox PDF Cloud viewer add on	Total
1	About	1	0	1	2
2	Accounts	0	1	0	1
3	Annotation	0	4	0	4
4	Bookmarks	0	1	0	1
5	Search Metadata	0	6	0	6
6	Additional keyboard shortcuts	17	11	4	32
7	Reading	16	11	8	35
8	Search etext	0	1	0	1
9	Table of Contents	0	1	0	1
Total		34	36	13	83

The following four features were also mapped between the Bureau van Dijk reader and the Firefox PDF cloud viewer add on:

1. Zoom in;
2. Zoom out;

3. Margins slider; and
4. Text and background colour theme.

The final outcome suggested that the VoiceDream reader and the Firefox mobile browser were candidates for the academic and student use case walkthroughs. These were undertaken for each print impairment type for specific accessibility settings and revealed the number of potential barriers that could be encountered by a user with print impairments within the mobile web HEI library ecosystem. The number of steps (tasks) were counted for the entire process for each print impairment use case. Table 11 provides an overview of the number of potential barriers for each use case walkthrough. See Appendix G for the detailed breakdown. The sub-totals and grand total scoring has been included to provide an overview of the number of potential barriers as well as a breakdown where combinations of features would be required.

Table 11: The total number of potential barriers based on print impairment type against the five new framework components. Continued on next page.

Print impairment type and accessibility feature	New framework component					Potential barrier total
	Discovery	Search Metadata	Econtent Format	Ereader	Econtent	
Blind and visually impaired:						
Screen reading	12	3	2	8	2	27
High contrast	14	3	3	4	1	25
Colour correction (colour blindness)	13	3	3	4	1	24
Magnification gestures	13	3	3	4	1	24
Increase font size	11	3	3	4	1	22
Sub-total						122

Table 11 continued. Dyslexia:						
TTS (2 steps required the use of TTS).	13	4	3	7	2	29
Margin, line, character spacing	13	4	3	13	1	34
Read along	14	4	3	11	2	34
Themes	13	4	3	11	1	32
Sub-total						129
Physical difficulties:						
Switch access control	11	4	4	6	2	27
Sub-total	127	35	30	72	14	
Sub-total						27
GRAND TOTAL						278

The least number of steps was 22 for increasing font size; whereas margin, line and character spacing, and the use of read along both had 34 steps. TTS was required for two steps under the dyslexia category. The remaining 27 steps were also indicated in Table 10 because the user was still required to undertake the navigation and input tasks to get, for example, to the abstract preview of an ejournal paper where TTS could be used. The other step where the user required TTS was in reading the etext within the ereader application. The discovery (127) and ereader (72) framework components indicated the greatest number of barriers. The overall results from this analysis informed the development of Expert Review One and saw the emergence of an instrument.

Expert Review One results enabled the physical and sensory control categories, incorporating issues arising for dyslexia, to then be determined. In total 12 expert participants (n=12), 5 male and 7 female, agreed to take part in Expert Review One. This was at the upper limit specified (Hwang and Salvendy, 2010) before diminishing returns become evident as referred to by Nielsen and Molich (Nielsen and Molich, 1990). The demographics and expertise data follows in Table 12.

Table 12: Expert Review One demographics and expertise data.

Gender	Male	Female	Total
	5	7	12

Age Range	18-29	30-49	50-64	65+	Total
	2	9	1	0	12

Subjective Knowledge (SK) Rating Domain knowledge or expertise (Likert scale rating)	1	2	3	4	5	Total
	0	1	8	2	1	12

Worked as consultant/specialist	Less than 2 years	2-5 years	6-10 years	11-15 years	16+	Total
	1	3	4	4	0	12

Response	Yes	No	Total
Tested more than 10 web sites for accessibility?	5	7	12
Tested mobile applications/browsers for accessibility?	7	5	12
Tested mobile devices for accessibility?	7	5	12
Do you use an ereader for reading academic etexts?	9	3	12

Eight expert participants gave a neutral score for the subjective knowledge (SK) rating, whereas three participants gave a score of 4 and above, where a score of 1 was the least expertise and a score of 5 the greatest expertise. The experience of the individual experts ranged from less than two years up to a maximum of 15 years, with eight of the 12 participants having six or more years of experience in the alt-format domain. The results for the expert who had less than two years' experience were not included in the subsequent analysis. Five of the 12 participants had tested more than 10 websites for accessibility. Seven of the participants had tested ereader applications and browsers for accessibility. Seven of the expert participants had tested mobile devices for accessibility. Whereas, nine of the participants had used an ereader application for reading academic etexts.

Subjective Knowledge was scored on a Likert scale of 1 to 5. SK scores of 3 and below may suggest that certain experts did not feel their expertise matched the area being covered in the survey. In other instances the SK scoring and number of years is identical for more than one expert participant. 10 expert participants commented on the physical and sensory control categories as indicated in Table 13, and this data was mapped against the expertise of the participants.

Table 13: Physical and sensory control categories overview mapped to expertise.

Continued on next page.

Control category name as extracted from comments	References coded	Participant(s) subjective domain knowledge and experience in years.
NAVIGATION	1	1. SK 4. 6-10 years.
Touch control	3	1. SK 3. 11-15 years. 2. SK 4. 6-10 years. 3. SK 3. 11-15 years.
Voice recognition	2	1. SK 3. 2-5 years. 2. SK 3. 6-10 years.

Table 13 continued.		
Control category name as extracted from comments	References coded	Participant(s) subjective domain knowledge and experience in years.
VIEWING THE SCREEN	3	1. SK 3. 11-15 years. 2. SK 5. 11-15 years. 3. SK 4. 6-10 years.
Zoom, reflow & reading order	9	1. SK 2. 11-15 years. 2. SK 3. 2-5 years. 3. SK 4. 2-5 years.* 4. SK 4. 6-10 years. 5. SK 3. 6-10 years. 6. SK 3. 2-5 years.* 7. SK 3. 2-5 years.* 8. SK 4. 2-5 years.* 9. SK 3. 11-15 years.
Colour changes	9	1. SK 2. 11-15 years. 2. SK 3. 2-5 years. 3. SK 4. 2-5 years.* 4. SK 4. 2-5 years.* 5. SK 3. 6-10 years.* 6. SK 3. 6-10 years.* 7. SK 4. 6-10 years. 8. SK 3. 6-10 years. 9. SK 3. 2-5 years.*

Table 13 continued.		
Control category name as extracted from comments	References coded	Participant(s) subjective domain knowledge and experience in years.
VIEWING THE SCREEN (continued)		
Font size (includes type)	3	1. SK 4. 2-5 years. 2. SK 3. 6-10 years. * 3. SK 3. 6-10 years. *
Images of text	1	1. SK 3. 6-10 years.
Colour contrast	1	1. SK 3. 11-15 years.
AUDIO AND ALTERNATIVE ACCESS	1	1. SK 4. 6-10 years. (Simplification was categorised under alternative access).
Voice feedback & TTS	7	1. SK 2. 11-15 years. 2. SK 3. 2-5 years. * 3. SK 4. 2-5 years. 4. SK 3. 11-15 years. * 5. SK 4. 6-10 years. 6. SK 3. 2-5 years. * 7. SK 3. 11-15 years. *
Hearing	3	1. SK 3. 11-15 years. 2. SK 5. 11-15 years. 3. SK 4. 6-10 years.
Simplification (this single comment does not refer specifically to alternative access).	1	1. SK 5. 11-15 years.
Read Along	1	1. SK 5. 11-15 years.

11 expert participants commented on the category principles and these were then mapped to the expertise of the reviewers see Table 14.

Table 14: Category principles overview mapped to expertise.

Principle name as extracted from comments	Occurrence	Participant(s) subjective domain knowledge and experience in years.
LABEL OF DISABILITY	1	1. SK 5. 11-15 years.
INCLUSIVITY	2	1. SK 4. 2-5 years. 2. SK 4. 6-10 years.
IMPROVING FUNCTIONALITY	1	1. SK 5. 11-15 years.
Process flexibility	1	1. SK 3. 6-10 years.
Adaptive	1	1. SK 4. 6-10 years.
Adaptable	3	1. SK 2. 11-15 years. 2. SK 3. 11-15 years. 3. SK 3. 6-10 years.
Levels of access & restrictions	4	1. SK 3. 2-5 years. 2. SK 3. 6-10 years. * 3. SK 3. 6-10 years. * 4. SK 3. 6-10 years.
Expected controls & outcome	2	1. SK 3. 2-5 years. 2. SK 3. 2-5 years.

* Indicate separate comments made by the same expert participant.

This was then followed by Thematic Analysis requiring six stages as suggested by Braun and Clarke (Braun and Clarke, 2006).

Stage 1: Familiarisation with Data, was undertaken revealing general findings about the qualitative data gathered in the expert review survey. In terms of the physical and sensory control categories, three general areas were identified, namely:

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1. Navigation;
2. Viewing the screen; and
3. Audio and alternative access.

Table 15: Thematic code list for physical and sensory control categories, incorporating issues arising for dyslexia.

FUNCTIONAL CATEGORIES - FC			
No.	Theme name	Theme code	Definition
1.	NAVIGATION	FC-NAV	
2.	Touch Controls	FC-TchCntrl	
3.	Voice recognition	FC-VoiceRecog	
4.	VIEWING THE SCREEN	FC-VIEWSCRN	
5.	Zoom, reflow, reading order	FC-ZmRflwRdOrd	
6.	Colour Changes	FC-ColrChngs	
7.	Font size (incl. type)	FC-FntSize	
8.	Images of text	FC-ImgTxt	
9.	Colour contrast	FC-ColCntrst	
10.	AUDIO & ALTERNATIVE ACCESS	FC-AUD-ALTACCESS	
11.	Voice feedback & TTS	FC-VoiceFdbckTTS	
12.	Hearing	FC-HI	The user is able to hear what they are accessing.
13.	Simplification	FC-Smplifi	The user is able to simplify content.
14.	Read along	FC-RdAlong	

Table 16: Thematic coded list for category principles.

CATEGORY PRINCIPLES - CP			
No.	Theme name	Theme code	Definition
1.	LABEL OF DISABILITY	CP-LBLDIS	
2.	INCLUSIVITY	CP-INCL	
3.	IMPROVING FUNCTIONALITY	CP-IMPROV-FUNC	
4.	Process flexibility	CP-PrccsFlex	
5.	Adaptive	CP-Adaptive	
6.	Adaptable	CP-Adaptable	
7.	Levels of access & restrictions	CP-LvlAccssRestrict	
8.	Expected controls & outcome	CP-ExpCtrlOutcome	

The principles behind the categories revealed three general categories, namely:

1. The label of disability;
2. Improving functionality; and
3. Inclusivity.

Stage 2: Generating initial codes, provided 14 theme codes for the physical and sensory control categories, see Table 15; whereas eight theme codes were created for the category principles, see Table 16. These were used when coding qualitative statements in preparation for analysis using NVIVO.

Stage 3: Searching for themes, was undertaken in conjunction with the use of NVIVO coverage percentages and analysis of the anonymised coded statements. According to NVIVO, the coverage percentage indicates how much of the source content is coded at a specific node. The node is a theme or idea that has been identified. The following provides a summary of the anonymised coded statements, see Table 17. Refer to Appendix C for the detailed breakdown of the anonymised coded statements.

Table 17: Summary of anonymised coded statements. Continued on next page.

Coding	Functional category summarised statement(s)
FC-ZmRflwRdOrd	9 references coded [16.23% Coverage]
FC-ColrChngs	9 references coded [16.11% Coverage]
FC-VoiceFdbckTTS	7 references coded [9.21% Coverage]
FC-TchCntrl	3 references coded [7.42% Coverage]
FC-VoiceRecog	2 references coded [6.91% Coverage]
FC-HI	3 references coded [5.04% Coverage]
FC-VIEWSCRN	3 references coded [5.01% Coverage]
FC-FntSize	3 references coded [2.76% Coverage]
FC-Smplifi	1 reference coded [2.16% Coverage]
FC-ImgTxt	1 reference coded [1.91% Coverage]
FC-RdAlong	1 reference coded [1.56% Coverage]
FC-ColCntrst	1 reference coded [1.40% Coverage]
FC-NAV	1 reference coded [0.64% Coverage]
FC-AUD-ALTACCESS	1 reference coded [0.19% Coverage]

Table 17 continued.

Coding	Category principles summarised statement(s)
CP-LvlAccssRestrict	4 references coded [29.22% Coverage]
CP-Adaptable	3 references coded [24.99% Coverage]
CP-ExpCtrlOutcome	2 references coded [16.67% Coverage]
CP-INCL	2 references coded [9.46% Coverage]
CP-Adaptive	1 reference coded [7.03% Coverage]
CP-PrcssFlex	1 reference coded [4.11% Coverage]
CP-LBLDIS	1 reference coded [3.83% Coverage]
CP-IMPROV-FUNC	1 reference coded [1.97% Coverage]

Stage 4: Reviewing themes, required a complete review of the qualitative statements provided by the individual experts. This revealed sub categories and groups of accessibility features referred to in the statements. For example, within the ‘viewing the screen’ category, nine references were coded for zoom, reflow and reading order, and again for colour changes. Whereas seven references were coded for Voice feedback and TTS. The coded references were further substantiated by the participants experience in years, where the more experienced experts predominantly provided the parent categories. For example, in the ‘viewing the screen’ category, three expert participants had an experience range of 6-15 years. Whereas the accessibility feature group for zoom, reflow and reading order had three expert participants with 2-5 years working experience.

Stage 5: Defining and naming themes, produced two final thematic maps based on the qualitative statements made by the individual experts, indicated in Figure 17 and Figure 18 respectively. The rectangular boxes denote primary themes and the rounded corner boxes denote secondary themes. Although Figure 17 indicates three physical and sensory control categories, alternative access is referred to in the audio and alternative category. Alternative access, in this instance, covers cognitive impairments such as dyslexia.

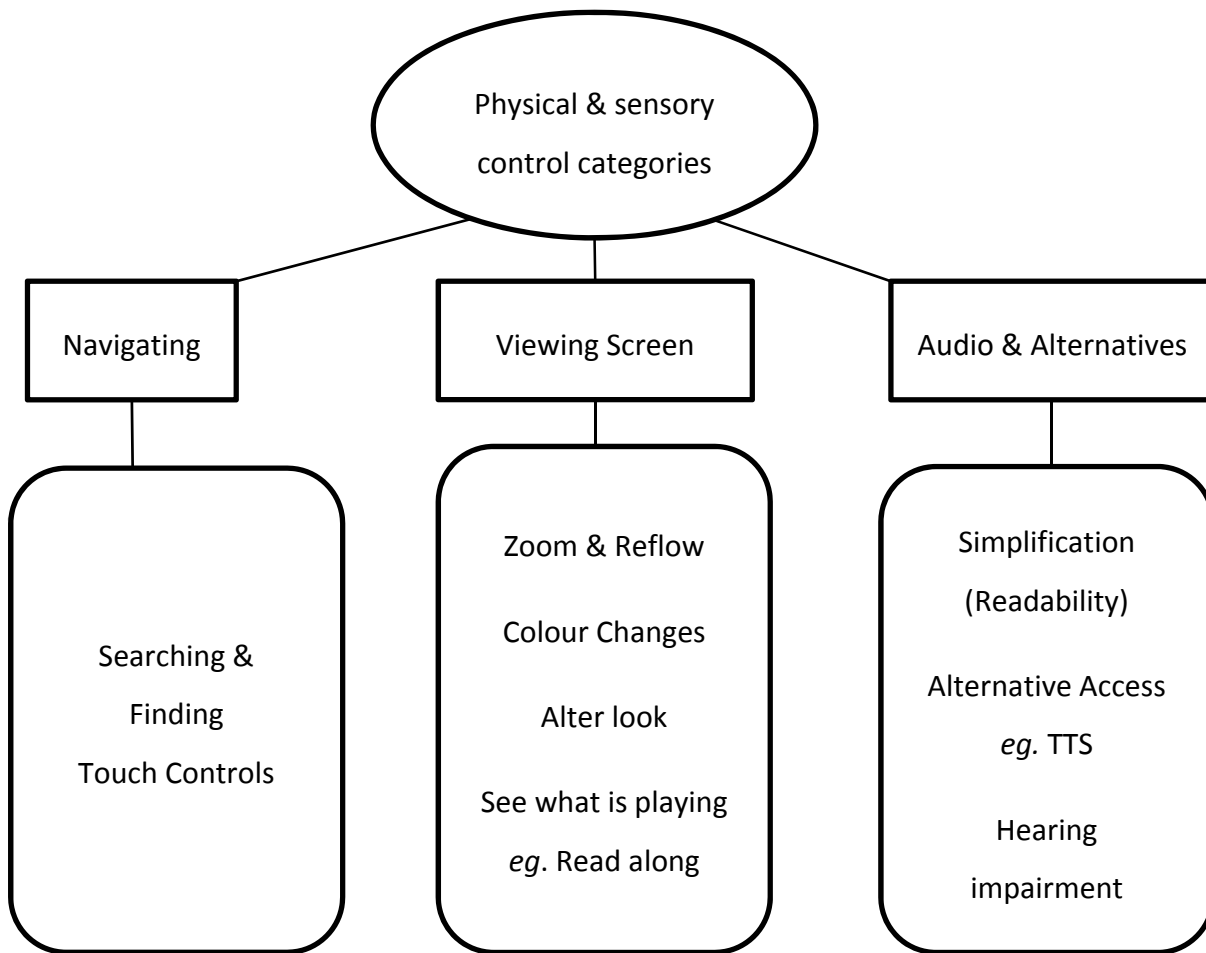


Figure 17: The final physical and sensory control category thematic map.

Figure 18 indicates three primary principles that would be required to develop criteria for mobile web accessibility standards and guidelines.

Stage 6: Producing the report. Three expert participants involved in Expert Review One provided a basis for the physical and sensory control categories that support a framework for the mobile accessibility settings referred to in *RQ1*.

RQ1: What physical and sensory control categories support automatically evaluating the mobile web accessibility of Higher Education electronic texts for print impairments?

Although 12 expert participants were involved in the review, only the feedback from 10 were included in the qualitative analysis because their comments were either not complete or insufficient when asked about the physical and sensory control categories. Nine participants referred to visual controls, although the terminology varied among the

individual expert participants the terms used referred to the same thing. For example, two expert participants suggested the following for physical and sensory categories: ‘can I alter the look of what I am accessing’ and ‘viewing the screen’ referred to a visual control category.

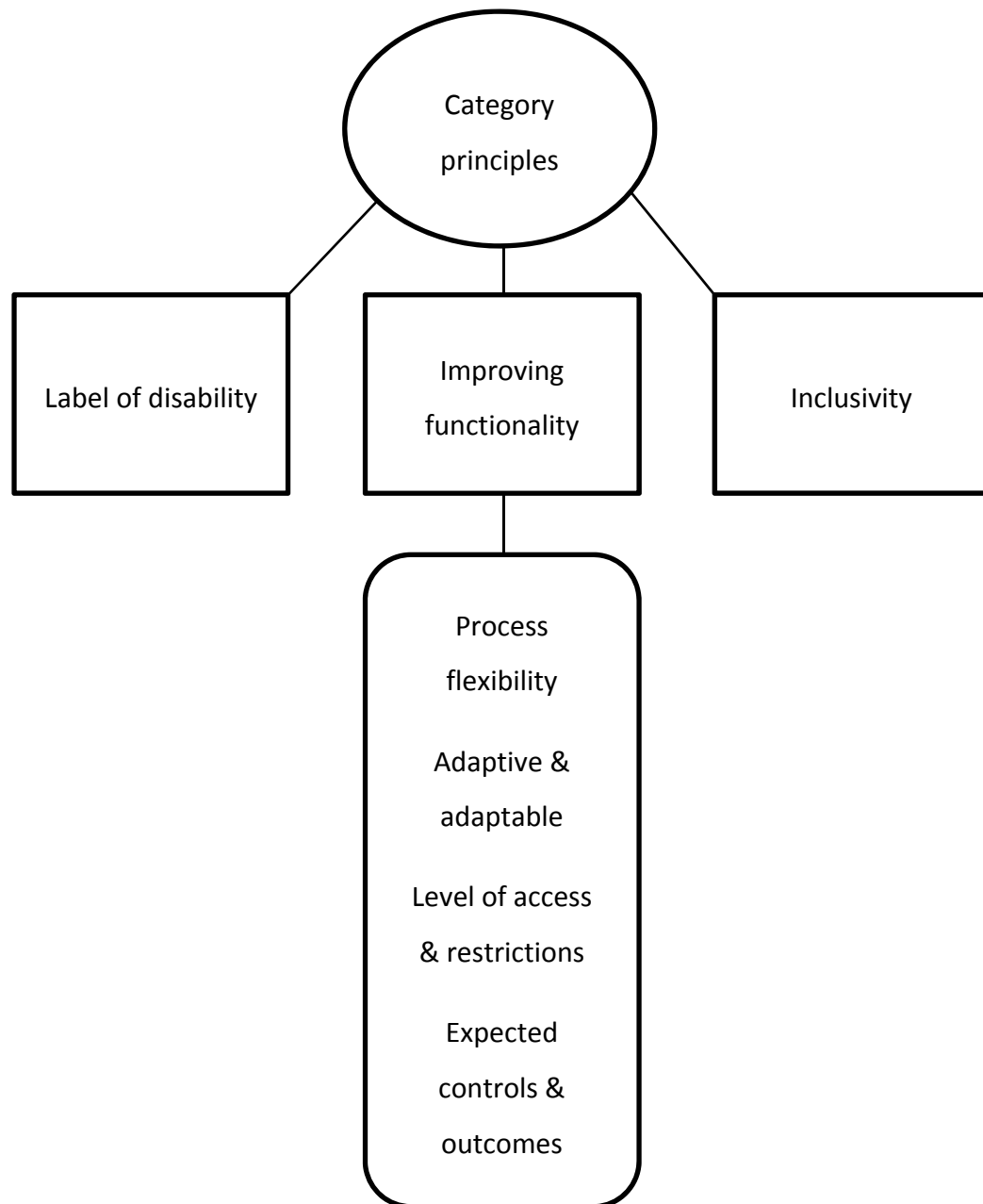


Figure 18: The final category principles thematic map.

The following extracts from the survey data epitomise the physical and sensory control categories, and incorporate an essential accessibility requirement for dyslexia as recommended by (Rello et al., 2013), namely simplification.

Extract 2:

- 'Can I alter the look of what I am accessing?
- Can I hear what I am accessing?
- Can I simplify what I am accessing?
- Can I see what is playing?'

Extract 3:

- 'Navigation
 - Finding what the user requires
 - Touch Controls – relating to dexterity or motor impairments
- Viewing Screen
 - Zoom and Reflow
 - Colour Changes
- Audio and Alternative Access
 - Alternative Access – includes the use of TTS and reading order.
 - Hearing'

Extract 4:

- 'Ability to customise for a range of visual impairments or speech settings.
- Vibrate settings for hearing impairments.
- Alternative options for touch screens for physical difficulties with standard interface.'

Three similarities can be found between the above extracts enabling them to be overlapped. The phrases, 'can I alter the look of what I am accessing', 'can I see what is playing' and the 'ability to customise for a range of visual impairments or speech settings' could be placed under the category 'viewing screen' in the second extract. Secondly, the phrase 'can I hear what I am accessing' and 'vibrate settings for hearing impairments' would be accommodated under the 'audio' category in the second extract. Finally, the phrases 'can I simplify what I am accessing' and 'alternative options for touch screens for physical difficulties with standard interface' can be placed under the category 'alternative access.' This provided four main categories:

- ***‘Navigation***
 - Finding what the user requires
 - Touch Controls
 - Alternative options for touch screens for physical difficulties with standard interface.’
- ***Viewing Screen***
 - Can I alter the look of what I am accessing?
 - Zoom and Reflow
 - Colour Changes
 - Can I see what is playing? (This could refer to the fact the user may need to activate TTS in the eReader user interface (UI) by selecting a ‘play’ button. This may also activate overlays whereby the text that is read aloud is highlighted as it is read by the device.
 - Ability to customise for a range of visual impairments or speech settings.
- ***Audio***
 - Hearing: Can I hear what I am accessing?
 - Vibrate settings for hearing impairments.
- ***Alternative Access***
 - Includes the use of TTS.
 - Can I simplify what I am accessing?’

Extracts 1 and 3 did not explicitly refer to Navigation. The remaining individual expert participants, however, reinforced different aspects of the extracts above, through practical applications of the interactions that can take place between users and digital library content. Extract 5 provides three examples of those practical applications.

Extract 5: Examples of practical applications

- ‘Navigation options are required with the ability to alter size of buttons.
- Font adjustment: including font size, colour and style alongside background colour change and the reflow of text.
- Reading order.’

There was agreement between the participants involved in the expert review survey relating to the principles that govern the physical and sensory control categories. The dominant themes are provided in the following extracts:

Extract 6:

- ‘Principles should be driven by how the user thinks about their access needs. Some will think about it in terms of the label of their disability while some will think about the functionality they are trying to improve. Teachers and professionals supporting users are likely to focus on the label of the disability.’

Extract 7:

- ‘Inclusiveness, personalisation and efficiency options – ie. human centred and use centred design.’

The remaining experts identified that equality across all devices and settings was mandatory, this would come under the theme ‘Inclusiveness’ indicated in Extract 6 above. One expert, however, verbalised why by stating that the principles need to be:

Extract 8:

‘Generic across platforms. Similar functionality (should respond in the same way). Expected controls and outcomes.’

5.1.1 Summary for Expert Review One results

Expert Review One was designed to answer RQ1 by using Thematic Analysis as suggested by Braun and Clarke (Braun and Clarke, 2006). Four overarching themes were identified during this survey, namely:

1. Navigation;
2. Viewing the screen;
3. Audio; and
4. Alternative access.

Alternative access included components such as TTS and simplification, such as presenting synonyms on demand. These are considered essential accessibility requirements for dyslexia by Rello and Baeza-Yates (2014). The results indicate that these

four themes were identified by the most experienced expert reviewers, and secondary themes were identified by less experienced participants.

5.2 Discussion

The technology neutral core device mobile web accessibility features relating to HE and print impairments were mapped across three mainstream devices, namely the:

1. Android (Nexus 5);
2. iOS (iPhone 6);
3. Windows phone (8.1).

The reason for this was to determine what accessibility support already exists within the mainstream mobile domain with an emphasis on reading etexts in HE. 24 core accessibility settings were identified through mapping. The Windows phone 8.1, at the time of writing, did not support 15 features that both the Android and iOS platforms supported, in particular switch access control. Another main feature of the two other devices that the Windows phone 8.1 did not include was the Android global and local context menu tool and the iOS rotor tool.

These tools allow the user to navigate at a high or low level depending on the granularity required. For example, the Android global context menu allows the user to access specific navigation settings on screen, such as 'Read from top'. This reads out aloud each item available to the user on the screen as stated by Swan (2015). This tool also enables rapid access to both the on board screen reader, referred to as Talkback, and the TTS settings through a circular dial as referred to by Swan (2015).

The Android local context menu, however, enables the user to read out aloud on screen content, such as page, paragraph, line, word and character level if required as specified by Swan (2015). Clearly these device features lend themselves to the support of accessible ereading within an HE environment.

The iOS rotor combines both the global and local components of the Android device into one tool. These tools do, however, rely on third party applications recognising that the device has this feature available and that these device features are given permission to

Chapter 5: Framework results and discussion

access internal navigational menus within the application. For example, the researcher tested whether the Blio ereader application on the Android Nexus 5, version 6.0.1, allowed the local context device menu access to the content and the navigational elements within the application. This was found to be the case. Although not exhaustive the majority of the ereader applications analysed operate across all three operating systems.

The Windows phone 8.1 offered high contrast; whereas the Android and iOS mobile devices only made provision for colour inversion. There is a distinct difference between the two features. For example, colour inversion, as the name suggests, inverts the colours shown across the entire screen as if an overall filter has been applied.

Colour inversion also provides a negative of images shown on screen, rather than keeping the image in its original state while the surrounding content is inverted. High contrast, however, enables the user to customise the text separately from on screen images. The Windows phone 8.1 also provides high contrast themes that override third party applications running on the device.

It is not to say that there are settings, such as Ignore Repeat for switch access control, that should be excluded but only the iPhone had this setting available. Another setting in this category was Highlight Content (overlays by media query for read along), available for iOS 9.1. On the Nexus 5, there is a setting for managing custom labels for images. There is no equivalent in iOS 9.1. Having said that there is reference to button 'labels' under accessibility. Also in the context menu (Android) or rotor menus (iOS) the Android has the setting to read at paragraph level and the iPhone does not. The iPhone has the option to read at heading level and the Android phone does not.

During the testing phase for the ereader component of the instrument a manual test was undertaken that was related to the use of the PDF and EPUB3 format across 10 ereader applications. These applications were supported by the three mainstream mobile platforms, namely: Android, iOS and the Windows smartphone. Although not an exhaustive sample, this shows that mainstream ereader applications can recognise the EPUB3 format. This corroborates the statement made by Kasdorf that reading systems support this format, and that there is no longer any need for publishers to keep using the

EPUB2 format (Kasdorf, 2017). According to the Daisy consortium the EPUB3 format has completely embraced the accessibility features found within the DAISY standard (DAISY, 2018). The epubtest.org website provides a crowdsourced evaluation of ereaders that support the EPUB3 format. Recently the ACE EPUB3 accessibility evaluation tool has become available.

Alongside this, support for the existing PDF format was corroborated. There is also a PDF/UA reference suite (PDFA, 2014) that provides PDF's that comply with the PDF/UA standard ISO 14289-1:2014, but unfortunately does not go as far as the ePubtest.org by stating what ereaders have been tested. The PAVE and PAC3 tools enable the accessibility evaluation for the PDF format but are limited as to the complexity of the PDF that can be evaluated, particularly when including STEM content.

During the mapping of core accessibility settings across 10 ereader applications, the Bluefire reader was the only ereader that exposed a single aspect of accessibility metadata. It enables the user to determine the permissions set by the academic publisher for the particular format being read. For example:

- Allowing the user to view the etext on any device;
- Allowing the user to copy/paste any text on any device; and
- Allowing the user to print on any device.

The researcher obtained this information through manual testing of the Bluefire reader mobile application operating on an Android device. Although limited, this does demonstrate that accessibility metadata can be made available in human readable form to the user. This information is currently only available within the application. If, however, this type of information was exposed directly on the academic publishers' mobile websites the user could determine if the format would meet their accessibility requirements prior to download.

Adobe has made provision for publishers generically to incorporate an accessibility report within the format, a report that is generated when the publisher uses the PDF accessibility checker (Adobe, 2012). Garrish states that the EPUB3 format also makes accessibility metadata available (Garrish, 2012).

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The Dyslektz ereader had problems with authentication and crashed when attempting to run the application. The IDEAL Group Reader was sporadic, opening at times but also crashing at times. The Bureau van Dijk Reader (Publizard) native app, Ebscohost and Overdrive Media Console required an institute account.

The paid for Android version of VoiceDream has less features made available than the paid for iOS counterpart. There is a lite version of VoiceDream for iOS. The Bluefire reader app for iOS allows text and background colour to be altered for EPUB3's; whereas the Android version does not. The Android version of Adobe Acrobat Reader has been included simply because of its mainstream usage and that it provides reflow; whereas the Android Adobe Digital Editions does not currently provide this feature.

In terms of the accessibility settings supported by over half of the ten ereader applications it would appear that the reason the EPUB3 format is more flexible than the PDF is because features such as text and background colour can be easily altered. However, if the VoiceDream reader is used the text within a PDF can be scraped and then redisplayed based on customised text and background colour settings.

Although through physical testing it was found that yellow text on a black background was prevented in the Voice Dream reader even though the customisation of other colours was possible. This configuration of text to background colour appears to be locked because it can only be altered in the proprietary software platform Adobe Acrobat Standard or Professional version.

Online ereaders also exist, such as Radium and the Publizard beta version, that operate on all devices since they are web based. The Publizard beta version is heavily limited in terms of its functionality and would not give a representative result if evaluated with the instrument.

Mapping the core accessibility settings across the mainstream Android mobile browsers identified the paucity of the accessibility features available to this group of UAs. This may in part be due to the legacy of minimising the impact on the devices OS for early mobile devices that had limited storage and memory capabilities as stated by IRMA (2017). 'Text scaling' and 'always enable zoom' were the two most commonly available features on the

mobile browsers. Text scaling took the form of either a sliding mechanism or an incremental plus and minus feature for altering text size. Force enabling zoom overrides a mobile website that has disabled zoom. When both of these features are set correctly, prior to opening a mobile web page using the browser, the preferences are carried through for all subsequent pages opened within the mobile browser. In addition to this the mobile browsers Firefox and Chrome enable voice input in the browser address bar and is useful for undertaking searches especially for those with motor impairments.

The two online readers Radium and the Bureau van Dijk (BvD) beta version, however, provided significantly more functionality in terms of the features made available through external keyboard activated settings. The BvD provided 43 distinct settings; whereas Radium offered 36 overall that related to ereading within an HEI library context, such as making provision for search metadata options. Both online readers make provision for full screen reading.

Academic and student use case walkthroughs were undertaken to determine what mobile device accessibility features were available for those with print impairments using an Android device. These were specific to using an HEI library web portal accessed on the same device, and counting the number of steps (tasks) required to search for, find, download, navigate and read an etext from an HEI library portal on an Android device. The number of steps was remarked upon in the published research findings as being significant (McNaught et al., 2010). Each of these steps constitutes a task that potentially could be a barrier if accessibility is not considered for the user.

Undertaking the walkthroughs not only provided the foundation for an instrument but the outcome of the instrument provided a set of automatic BW success criteria. This was then used to write the specification for an automatic mobile web accessibility evaluation tool. Five components were identified while undertaking the walkthroughs, namely:

1. Discovery;
2. Metadata (search only);
3. Econtent format;
4. UA Ereader; and
5. Econtent.

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These components could then be subdivided into specific tasks to be undertaken by the print impaired academic or student user within an end to end process. This process also further contributes to the BW success criteria to be evaluated. For example, discovery involves searching for and finding an etext through the use of an HEI library web portal that then hands over to an academic publisher's website. This process begins with authentication where the academic or student user is required to log in, in this instance with a mobile web browser.

Cross platform mobile web browsers provide accessibility features, albeit in a limited way, but these settings are essential in the evaluation process, particularly if these features can be detected automatically. Undertaking the walkthroughs helped to expose this particular aspect but also identified the limited use of accessibility metadata across the mobile web accessibility HE etext ecosystem.

Although academic publishers make provision for the use of search metadata on their respective platforms (Beyene and Godwin, 2018) there is limited exposure as to what accessibility metadata is made available by mobile devices, mobile browsers, ereader applications and online readers.

Expert Review One required the participants to provide a Subjective Knowledge (SK) rating based on a Likert scale of one to five. Statistical analysis of this data was not undertaken for two reasons:

1. Although there was a variance in the scoring, eight out of the 12 expert participants rated their SK on the neutral marker, the number 3.
2. The scale did not provide clear intervals, only stating opposite extremes and expecting the participants to infer the remaining scores.

Since eight experts chose the neutral marker this seemed to suggest that the participants were uncertain as to whether their expertise was relevant to the survey. Either that or the question and scale was not clearly defined and needed to be revised. Three participants did, however, provide an SK scoring of four and above, and so may have felt their expertise was relevant. It was for this reason that the SK scoring could only be used as an approximate indication of domain knowledge and expertise. Based on (Brajnik et al.,

2011), however, additional questions relating to actual experience provided a means to overcome the problem with the SK scoring. This was achieved by asking the participants five questions related to:

1. The number of years worked as a consultant/specialist within given ranges;
2. The number of websites tested for accessibility;
3. The number of mobile applications and mobile browsers tested for accessibility;
4. Whether the participant had tested mobile devices for accessibility; and finally
5. If the participant had used an ereader for reading academic etexts.

These provided a consistent means to identify overarching themes, and secondary themes, when mapped to the actual expertise of the participants. Two expert participants gave the following scores:

1. SK 4 with 6-10 years' experience; and
2. SK 5 with 11-15 years' experience.

The overarching themes were predominantly provided by these two expert participants, who also contributed to secondary themes. Although four overarching themes were identified by these experts they grouped audio and alternative access together. In certain instances when SK scores and expertise were provided more than one expert had the same scores.

The expert participant who gave an SK of four and an age range of 6-10 years specified 'navigation' as an overarching category but then specified that 'touch control' was a sub-category. Two other expert participants also referred to 'touch control' corroborating this theme. Navigation was also not isolated to touch alone, another expert referred to navigating by audio cues – an input by voice; although this was found to be limited to search features in the use case walkthroughs. Through inferences, see Figure 19, additional control categories could be derived based on the themes identified during thematic analysis.

Audio and alternative access, as can be seen in Figure 19, is linked to both visual and audio controls. Clearly audio is directly linked to audio controls; whereas alternative

access may require a combination of physical and sensory control categories. In this instance, alternative access may occur in both visual and audio control categories.

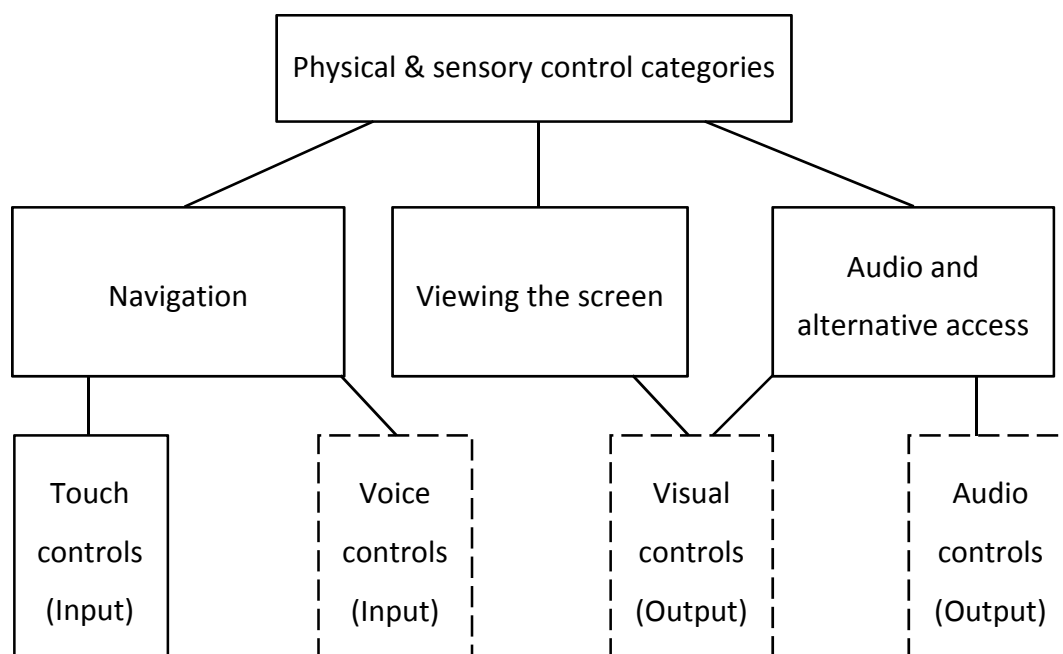


Figure 19: Physical and sensory control categories, including alternative access.

For example, a read along feature would need to be included in both visual and audio control categories; whereas TTS controls would be categorised under audio. There is a potential issue here, in that an additional control category could be introduced, namely cognitive controls. For example, the feature synonyms on demand – a form of simplification, would be included under cognitive controls, perhaps alongside elements such as decluttering of the screen.

This would increase the number of features to be evaluated and may impact stakeholder adoption as suggested by Vigo and Brajnik (2011). Whereas, the four physical and sensory control categories could remain, potentially improving stakeholder adoption (Vigo and Brajnik, 2011), but this increases the complexity of implementation.

In addition to this, the physical and sensory controls offer the user the ability to customise features on a mobile device according to their print impairment accessibility requirements. The physical and sensory control categories, have been incorporated into a framework, as shown in Figure 20, integrating device characteristics and is inline with

research undertaken by Vigo et al. (2008). It also contributes towards updating the MWBP 1.0 a request made by Kaur and Dani (2017).

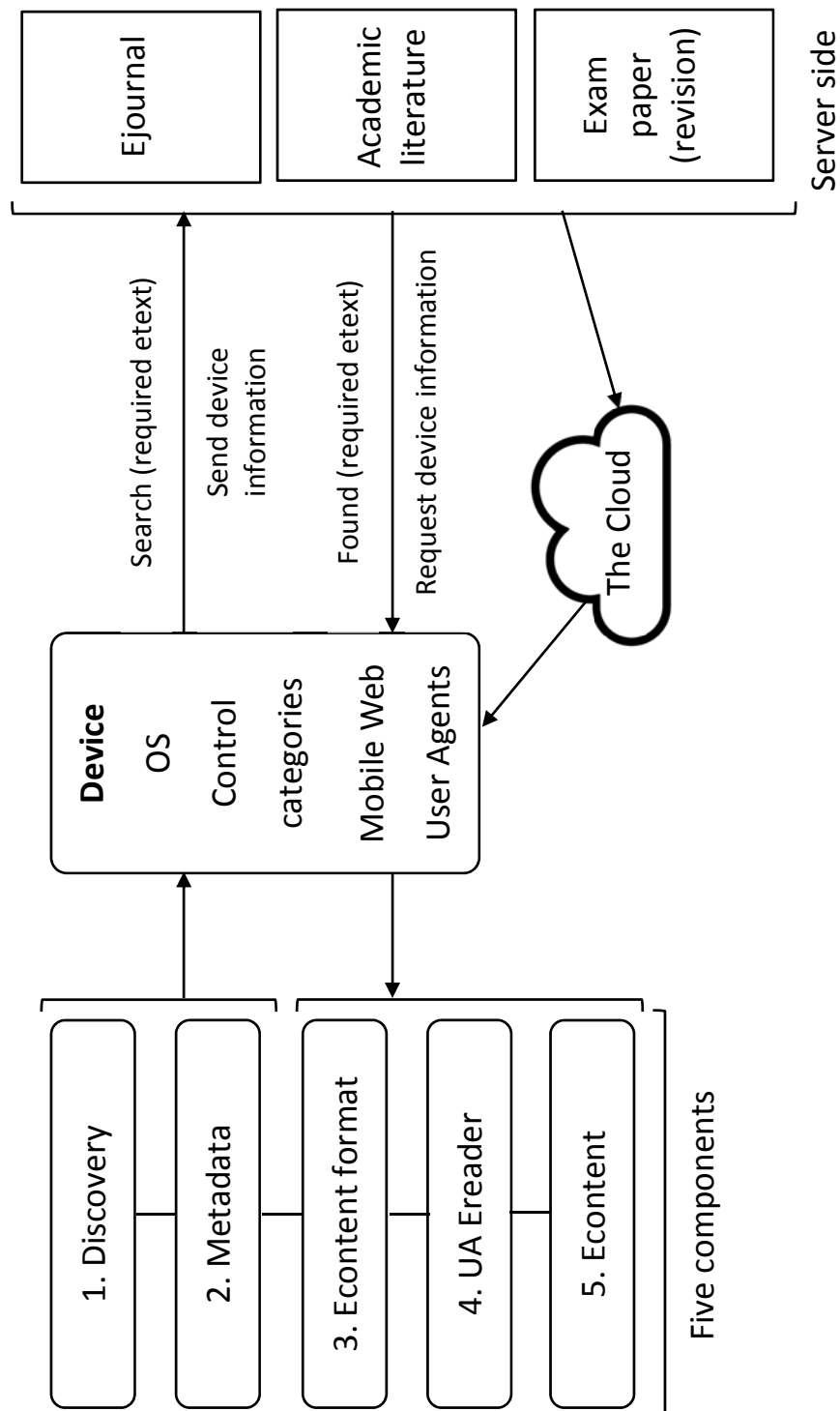


Figure 20: Automatic mobile web accessibility evaluation framework, integrating the device.

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The principles behind the categories have also been covered in the survey for Expert Review One respectively for the overview and qualitative statements. Three overarching themes were provided by the most experienced reviewers, namely:

1. Label of disability;
2. Improving functionality; and
3. Inclusivity.

One of the expert reviewers suggested that: 'principles should be driven by how the user thinks about their access needs. Some will think about it in terms of the label of their disability, while some will think about the functionality they are trying to improve. Teachers and professionals supporting users are likely to focus on the label of the disability.' The remaining principle draws attention to the fact that when addressing web accessibility every user ultimately benefits.

In order to visualise and to consolidate the complex interrelated components of this evaluation tool, a framework was developed by the researcher at this stage in the research. Figure 20 is an adaptation of that framework, with subsequent updating by altering the terminology used from the term 'layering' to that of 'components'. The reason for this change is that each component is not necessarily sequential, whereas 'layering' would suggest otherwise. For example, a search for a title may take place on Google Scholar or Project Gutenberg prior to accessing the institute platform.

5.2.1 Limitations

During the development phase of the automatic mobile web accessibility evaluation framework that integrates the device, access to mobile devices was limited. The researcher relied on a personal Android device for physical assessment and manual testing, particularly during the academic and student use case walkthrough stage. This was addressed by borrowing devices, when undertaking the mapping of core device accessibility settings. Three mainstream devices were selected, an Android Nexus 5, an iPhone 6 and the Windows Phone 8.1.

This was limited by the availability of devices the researcher had access to at the time. Each device required physical testing as suggested by Whitehouse (2011), but required a considerable amount of time to explore the devices and to establish what accessibility features were available by carefully examining each settings menu and subsequent sub menus.

One of the reasons why VoiceDream Reader was used was because it provided the greatest number of accessibility features. For example, it allowed both PDF and EPUB3 files to be opened. However, only the Bluefire Reader application enabled copy, paste and open on any device. This accessibility metadata is humanly readable within the application. Another ereader application had to be used for device testing during the use case walkthroughs because a full ereader application based on the instrument had not been developed and is part of the future work.

The main limitation for Expert Review One was that participants were all librarians and no academic publishers were present. The expert participants may have also been distracted undertaking the review during a break in the day. That being said it was the only time available in order to fill out the survey. In addition to this, the survey was undertaken by using hardcopy questionnaires and in some instances handwriting was difficult to read during qualitative analysis. In order to alleviate this issue for further data collection iSurvey, the University of Southampton's official data collection tool, was used for Expert Review Two. Only one coder was available for coding up the qualitative statements. The principles behind the categories was also not answered by one participant.

5.3 Chapter summary

The main finding from the Thematic Analysis undertaken for Expert Review One was four physical and sensory control categories, referred to in Table 18, for features made available through mobile device settings, namely:

1. Visual controls;
2. Touch controls;
3. Audible controls; and
4. Voice controls.

Table 18: Device & UA features categorised by physical and sensory controls.

Physical & Sensory Controls (incorporating issues for dyslexia)	WCAG 2.0 (example mapping)	Feature/Selector (Device & UA)	Input/Output
Visual controls	SC 1.4.3. (AA) SC 1.4.6. (AAA) SC 1.4.8. (AAA)	High Contrast, Brightness & Themes, Colour Filters - Font Style (includes import fonts)	Output
	SC 1.4.8. (AAA) SC 3.2.3 (AA) SC 3.2.4. (AA)	Layout (White Space) & Declutter (eg. Fullscreen) & Simplification (eg. Text analysis – (Rello, 2013): substitute complex words for simple words.) Also includes read along.	Output
	SC 1.4.4. (AA) SC 1.4.8. (AAA)	Text Size, Zoom/Magnification, Reflow (includes responsive web content)	Output
Touch Controls (Haptic navigation)	SC 1.3.3. (A) SC 2.1.1. (A) SC 3.2.1. (A)	Device Gesture (eg. moving focus when using a screen reader) & hardware (eg. volume button, Braille display, Bluetooth keyboard, switch control, haptic feedback) & screen orientation.	Input
Audible Controls	SC 1.3.1. (A) SC 3.1.5. (AAA)	Screen Reader & Text to Speech (TTS)	Output
	SC 1.3.1. (A)	Read Along (Media Overlay) – eg. VoiceDream.	Output
Voice Controls (Voice navigation)	SC 4.1.2. (A)	Voice Recognition	Input

The outcome of this was twofold; to either provide an additional control category for cognitive impairments or to incorporate the cognitive controls within the combination of

the physical and sensory control categories. The latter was chosen but this impacted the complexity of implementation. It also impacted the complexity of evaluation, if undertaken manually, but since an automatic evaluation process has been suggested then a control on the verbosity of reporting needs to be considered for stakeholders as stipulated by Ulltveit-Moe et al. (2008). This could impact stakeholder adoption as suggested by Vigo and Brajnik (2011).

Mapping the accessibility settings across mobile devices and UAs enabled core accessibility features to be identified that were then categorised according to these respective control categories. This was then taken forward by mapping the device and UA features to WCAG 2.0, at the time of writing, and specifying input and output functionalities, see Table 18. This incorporated device and UA characteristics into the framework, as indicated previously in Figure 16 and is in line with research undertaken by Vigo et al. (2008). Vigo et al presented a web accessibility evaluation tool that was technology neutral irrespective of the hardware, software and the UA characteristics (Vigo et al., 2008).

Each control category was then taken forward into an instrument that could then be analysed against user tasks. The user tasks related to the five new framework components and are referred to in Table 19, namely:

1. Discovery
2. Metadata;
3. Econtent format;
4. UA Ereader; and
5. Econtent.

These components refer to an academic or student searching for, finding, downloading, navigating and reading an HEI etext. The academic and student use case walkthroughs for each print impairment type corroborated the five new framework components from a user's perspective. They also highlighted the number of potential accessibility barriers that could be encountered by the user.

Table 19: User tasks mapped to the five new framework components.

Discovery (includes search metadata)	Metadata (eg. format accessibility metadata)		Econtent format	UA Ereader	Econtent
	PDF (Example tags)	EPUB3 (Example tags)			
1. Search & search result (Google). 2. HEI library authentication (Login). 3. HEI web portal steps/search. 4. Academic publishers website steps/search/preview paper abstract/ view accessibility metadata prior to download.	1. Fast web view. 2. Accessibility permission flag is set. 3. Accessibility report attached to document. 4. Document is tagged PDF. Includes navigation through headings (eg. H1 – H6). 5. Custom properties.	1. IDPF: Accessibility Summary (eg. contains MathML). 2. Onix Code 10 No reading system accessibility options disabled. 3. Onix Code 99: Publisher contact for further accessibility information.	1. Search result. Dialogue: 2. Manage downloads (includes DRM protected formats). 3. Third party storage	1. Authentication/ synchronisation. 2. View Format Metadata in UA. 3. Help. 4. Import etext, Library (etext Shelf) & Library Search. 5. Manage Local Downloads & Third Party Storage access within the UA. 6. Plugin Usage. 7. Document View & Screen Orientation. 8. Manage Bookmarks & Links Menu. 9. Progression & Lookup. 10. Search etext.	1. Table of Contents 2. Index 3. Heading (eg. H1, H2, H3 etc.) 4. Paragraph (eg. Paragraph >) 5. Line 6. Word 7. Character 8. Tables 9. MathML 10. ChemML

This saw the emergence of an instrument and was taken forward by specifying user tasks that related to the five new framework components, see Table 18. The final aspect of the instrument was the metric. It was based on two scores, firstly the number of steps evaluated out of an overall score of 25. Secondly, a total accessibility score is also provided as a percentage. The reason for this is that if a test is not applicable, it is not only recognised and recorded but does not impact the overall accessibility scoring. For example, the Gitden ereader mobile application requires a PDF plugin; whereas VoiceDream does not.

The developer using the automatic accessibility evaluation tool to develop an ereader for the HEI library that does not require a PDF plugin, would clearly not need to undertake this test. In this instance a hyphen would be manually placed in the instrument spreadsheet while testing the automatic BW success criteria for the accessibility evaluation tool. This records that a step is not applicable, and would be awarded 24 out of a maximum number of 25 steps. However, since the plugin test is not included the maximum scoring now becomes 24 steps. The success criteria that pass and fail are then given as a total accessibility percentage out of the 24 steps. Although this metric was developed it was not possible to evaluate it because it could only be achieved on a working mobile application allowing on device testing.

The final instrument, see Table 20 fold out, was the outcome of evaluating the physical control categories against the user tasks required on an HEI library web portal when using a mobile device and provided a matrix of automatic BW success criteria. The full version that includes comments can be found in: N.E. (2019) Dataset for: Automatically evaluating the mobile web accessibility of Higher Education electronic texts for print impairments. University of Southampton doi: 10.5258/SOTON/D1064 [Dataset] under 'INSTRUMENTEcontent2016.xlsx'.

This was the first iteration of the instrument and was subsequently updated. The metric measured the accessibility support available to mobile devices, ereader applications and mobile browsers within the HE etext ecosystem for those with print impairments. Based on the outcome of Expert Review One the main change to the instrument was the inclusion of the four physical and sensory control categories that incorporate issues

arising for dyslexia. In addition to this Expert Review One emphasised how navigation would need to be defined in terms of touch and voice input. This was the reason why input and output functionality for each of the four control categories were included in the instrument.

Another useful outcome of the control categories was that when the mapping of WCAG 2.0 success criteria was undertaken these too were also categorised according to the respective control categories. One of the outcomes of categorising the mobile device and UA features was the realisation that the instrument was reliant on a constantly changing and evolving mobile web ecosystem. Since this ecosystem is directly impacted by updates, different versions, new mobile devices and UAs a technology neutral approach was paramount. Two additional changes were required based on the use case walkthroughs. Firstly, it was found that search metadata and format metadata needed to be separated. The accessibility of the search metadata was found to be integral to the discovery component whereas the format metadata was integral to the econtent format component.

Secondly, the third component 'Download' was introduced because this required a specific user task to be performed to the etext format even though different aspects of downloading occurred in other components. For example, during Discovery, the user would be required to download the format selected on the publisher's website. The link provided on the mobile website to the format, such as a PDF, would need to be checked for accessibility. Whereas, the options in the UA ereader for download and managing downloads would also need to be tested. In addition to this, the mobile device in operation by the user would also require accessibility checks to ensure that applications such as Google Drive and Dropbox were accessible so that an etext could be downloaded.

Including the four physical and sensory control categories into the instrument enabled the mobile device features to be categorised. In doing so this integrated device characteristics into the instrument, incorporating the five new framework components, and is inline with the research undertaken by Vigo et al. (2008). It also helps to address the now 10 years old MWBP as requested by Kaur and Dani (2017).

Physical and sensory controls against user tasks	WCAG 2.0 (A,AA,AAA)	Feature/Selector (Device & Mobile Browser)	Input/Output	DISCOVERY						METADATA						ECONTENT FORMAT		UA EREADER								ECONTENT					Scoring																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																	
				Institute Authentication - Institute Library	Institute Portal Steps - Institute Library	Search 1 & Search 1 Result(s) - eg. Web of Science search	Search 2 & Search 2 Result(s) - Educational Publisher	Preview Paper Abstract - Educational Publisher	View Accessibility Metadata Prior to Download - Educational Publisher	PDF				ePub3		Dialogue		Third Party Storage	Authentication & Synchronisation	View Format Metadata in UA Help	Import eText, Library (eText Shelf) & Library Search	Manage Local Downloads & Third Party Storage access within the UA	Plugin Usage	Document View & Screen Orientation	Manage Bookmarks & Links Menu	Progression & Lookup	Search eText	Table of contents	Index	Heading (eg. H1, H2, H3 etc.)	Paragraph (eg. Paragraph)	Line, word, character	Tables	MathML & ChemML	Step (25 Overall User Tasks)	Total Accessibility (%)																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
										Fast Web View	Accessibility permission flag is set	Accessibility report attached to document	Document is tagged PDF	Custom Properties	IDPF: Accessibility Summary (eg. contains MathML etc.)	Onix Code 10: No reading system accessibility options disabled	Onix Code 99: Publisher contact for further accessibility information																				Search 2 Result - Publishers website.	Manage Downloads (includes DRM protected formats)																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																										
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1	Visual Controls	SC 1.4.3. (AA); SC 1.4.6. (AAA); SC 1.4.8. (AAA)	High Contrast, Brightness & Themes, Colour Filters - Font Style (includes import fonts)	Output																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												

Table 20: The first iteration of the instrument and metric.

Mapping accessibility settings across the mainstream mobile devices and mobile web UA's provided a technology neutral approach as recommended by the W3C (2018). This required an understanding of existing accessibility support by mapping features available on mainstream devices namely the Android, iOS and Windows smartphone operating systems. This resulted in 24 core accessibility settings that were mapped, at the time of writing to the three mainstream mobile device operating systems where possible. For example, The Android and iOS platforms provided switch access control; whereas this accessibility feature was not available for the Windows phone 8.1. Even though this was the case, the core accessibility setting 'switch access control' had been identified, and subsequent versions of the Windows phone would need to address this shortfall. However, according to Microsoft support for the Windows 10 mobile will end in December 2019 (Microsoft, 2019).

Undertaking this mapping also helped to identify one ereader application that exposed three aspects of accessibility metadata. These related to copying and pasting text, and whether the etext could be viewed on any device. In addition to this, assessing the UA accessibility settings across 10 main ereader applications also identified one core accessibility setting that is not currently available on the three main device operating systems and mobile browsers. This was the feature to show synonyms on demand, a feature available on the IDEAL ebook reader, Text4All and DysWebxia as referred to by Rello and Baeza-Yates (2014).

Chapter 6 Development of the instrument

This chapter provides each stage of how RQ2 was answered. The chapter begins with the design of the testing stages that determine whether the accessibility metadata for both the PDF and EPUB3 can be programmatically determined by AT. This was achieved by searching through existing standards for both the PDF and EPUB3. In addition to this the design of the device and mobile browser API accessibility support was determined by searching through API libraries online. It was important to undertake this because it not only exposes the availability of existing accessibility metadata but also emphasises areas for its future development.

The chapter then explains the method used for Expert Review Two, specifically the design of a survey that determines if the automatic BW success criteria, generated by the instrument, would work on an HEI library web portal when reading an etext on a mobile device. The purpose for the expert review was not a validation of the metric but a demonstration of how to use the specified accessibility metadata, the framework and the instrument.

6.1 Determining PDF and EPUB3 accessibility metadata programmatically

In Chapter 5 the Bluefire Reader was highlighted as being the only mobile ereader application that exposed accessibility metadata for both the PDF and EPUB3 format. Although it only allows the user to determine if the etext can be:

1. Printed;
2. That text can be copied and pasted; and
3. If it can be viewed on any device.

It does prove that accessibility metadata can be presented in human readable form within a mobile ereader application. Based on this finding three standards relating to the PDF and EPUB3 formats were carefully examined. These were BS ISO 3200-1:2008, the IDPF EPUB 3.0 accessibility standard and the ONIX code list 196. BS ISO 3200-1:2008 is the

standard for the Portable Document Format (PDF). Whereas the ONIX code list refers specifically to the accessibility of the EPUB3 format.

For example, BS ISO 3200-1:2008, states that the metadata tag 'MarkInfo' enables a machine to determine if a PDF document has been tagged (ISO, 2008). BS ISO 3200-1:2008 is the foundation for BS ISO 14289-1:2014 (or PDF/UA), the UA refers to Universal Accessibility.

If an accessibility metadata tag was found for specific accessibility requirements a page number or URL link was recorded for the relevant standard. The accessibility requirements met related to the accessibility features available within the respective PDF and EPUB3 formats. The accessibility metadata found also indicated that either the PDF or EPUB3 could be programmatically detected by AT, such as a mobile device screen reader.

6.1.1 BS ISO 3200-1:2008 accessibility metadata checklist

The accessibility features for the Adobe PDF relate to the 14 items that are checked within Adobe Acrobat Standard or Professional when the accessibility tool is run. These include:

1. Fast Web View;
2. Printing Allowed?
3. Content Copying for Accessibility Allowed?
4. Accessibility report attached to document?
5. Accessibility permission flag is set?
6. Document is not image-only PDF;
7. Document is tagged PDF;
8. Assistive Technology Support Enabled;
9. Document Structure Used for Tab Order;
10. Document Structure Provides Logical Reading Order;
11. Text language specified;
12. Document title showing in title bar;
13. Bookmarks present in large documents;
14. Document has appropriate colour contrast.

Fast Web View is a metadata tag that enables a PDF to be viewed in a mobile browser. In addition to this, six other properties were explored to determine if accessibility metadata was available, namely:

1. Custom properties;
2. PDF Producer (this referred to the software that created the PDF);
3. PDF Version;
4. Embedded fonts;
5. Creation date; and
6. Copyright status.

The custom properties enable an academic publisher to create their own property within the PDF. This could be used to provide contact details for further accessibility information. 20 specific accessibility features relating to ereading, within the PDF, see Table 21, were also investigated to determine if accessibility metadata tags were available, namely:

Table 21: Accessibility features relating to ereading within the PDF.

1. Page Layout;	11. Table of Contents
2. Background Colour;	12. Index
3. Line Height;	13. Headings
4. Text Decoration Colour;	14. Paragraph
5. Text Decoration Type;	15. Lists
6. Text Align	16. Label
7. Font Family	17. Link
8. Generic Font Family	18. Formula
9. Font Size	19. Zoom
10. Font Style	20. Full Screen

The reason for this was that Drümmer states that it is possible for a PDF reader or AT to represent a PDF, if it conforms to the PDF/UA standard, to display text that is

unformatted to any size and for this to be reflowed as required (Drummer, 2012). This can only be achieved within the Adobe Acrobat reader application through the use of pinch and zoom gestures when Reading Mode (Android) is activated.

Based on the PDF tag `FontSize`, found on page 580 of BS ISO 32000-1:2008, it appears that font size can be derived from the PDF. It could be used to recreate the same font size or to enlarge it when text is heuristically extracted from a PDF and redisplayed. It may also be possible to detect sentences as objects based on the same ISO standard on page 571.

The `Formula` tag (structure type) can be used to identify a formula as an entire content element and could be exposed within a mobile ereader application as containing STEM content. Unfortunately, however, there is no provision for further structure types within the formula (ISO, 2008). This means that the user would not be able to navigate through the formula within the PDF.

6.1.2 International Digital Publishing Forum (IDPF) EPUB 3.0 accessibility standard metadata checklist

Seven accessibility metadata tags were checked within the IDPF EPUB 3.0 accessibility standard. In the first instance certain tags were still pending, at the time of writing, but have subsequently been accepted by Schema.org. These included:

1. Access Mode
2. Accessibility Feature
3. Accessibility Hazard;
4. Accessibility Summary;
5. Access Mode Sufficient;
6. Accessibility API;
7. Accessibility Control.

The Access Mode, according to W3C is the *'The human sensory perceptual system or cognitive faculty through which a person may process or perceive information'* (W3C, 2018). The W3C state that the Access Mode Sufficient is a single list of *'combined access*

modes that are sufficient to understand all the intellectual content of a resource' (W3C, 2018).

6.1.3 ONIX code list 196 accessibility metadata checklist

The ONIX code list 196 provides accessibility metadata, see Table 22, used by the Publishing sector. 20 accessibility metadata tags were checked within the specified code list and included:

Table 22: ONIX code list 196 accessibility metadata.

1. Accessibility summary	11. Print-equivalent page numbering
2. No reading system accessibility options disabled (exception to EPUB3)	12. Synchronised pre-recorded audio
3. Table of contents navigation	13. Text-to-speech hinting provided
4. Index navigation	14. Language tagging provided
5. Reading order	15. Compliance web page for detailed accessibility information.
6. Short alternative descriptions	16. Trusted intermediary's web page for detailed accessibility information.
7. Full alternative descriptions	17. Publisher's web page for detailed accessibility information.
8. Visualised data also available as non-graphical data.	18. Compatibility tested
9. Accessible math content	19. Trusted Intermediary contact
10. Accessible chem content	20. Publisher contact for further accessibility information.

The accessibility summary enables the vendor to provide essential accessibility information about the EPUB3, such as what devices and or ereaders the format has been tested on.

6.2 Device and mobile browser API accessibility support

In order to determine if the device and mobile browser accessibility features could be detected programmatically, exposure of API accessibility metadata by OS and mobile browser were carefully examined.

This was achieved by searching through relevant API online libraries and existing guidelines. The libraries included the Apple and Android developer website alongside the Windows Dev Centre. The existing guidelines searched were WCAG 2.0, UAAG 2.0 and the ETSI EG 203350 Human Factors (HF) guidelines.

These were mapped to specific physical and sensory controls, incorporating controls for dyslexia, identified in Expert Review One. The three mainstream devices: Android, iOS and Windows smartphones alongside three cross platform mobile browsers: Chrome, Firefox and Opera were analysed.

In order to demonstrate how this was achieved Table 23 provides an example. Please see Appendix D for the detailed breakdown.

Table 23: Example of how the device and mobile browser API accessibility support was undertaken.

Search	Accessibility support outcome									
Can the following device and mobile browser features be detected programmatically?	Device			Mobile Browser					Exposed API accessibility metadata by OS	Exposed API accessibility metadata by mobile browser
	iOS	Android	Windows	Chrome	Firefox	Safari	Opera	Explorer		
Physical and sensory control category – For example Visual Controls: High Contrast (Windows Phone) versus colour inversion (iOS and Android)	✓ ✗	✓ ✗	✓ ✗	✓ ✗	✓ ✗	-	✓ ✗	-	iOS Referred to the Apple developer website API library. Android Referred to the Android developer website API library. Windows Referred to the Windows Dev Center API library. Expected Outcomes: Were mapped to WCAG 2.0 UAAG 2.0 ETSI EG 203350	Expected Outcome: Were mapped to WCAG 2.0 and UAAG 2.0

Chapter 6: Development of the instrument

The four physical and sensory control categories enabled the accessibility features available to both the three mainstream mobile devices and mobile browsers to be categorised in the following way:

1. Visual Controls:

1.1. Themes and styles:

- 1.1.1. High Contrast;
- 1.1.2. Brightness;
- 1.1.3. Text Colour;
- 1.1.4. Background Colour;
- 1.1.5. Colour correction/filter;
- 1.1.6. Pre-set Text Colour & Background Colour;
- 1.1.7. Font Family/Typeface.

1.2. Layout (white space) and declutter:

- 1.2.1. Margin Spacing;
- 1.2.2. Line spacing;
- 1.2.3. Character/Letter Spacing;
- 1.2.4. Left Justification (Ragged Right);
- 1.2.5. Full screen.

1.3. Resizing:

- 1.3.1. Text/font size;
- 1.3.2. Zoom/Magnification;
- 1.3.3. Reflow/Text or Word Wrap/Overflow Wrap/Thrashing.

2. Touch Controls:

2.1. Device gestures:

- 2.1.1. Moving focus using a screen reader during navigation.

2.2. Hard volume button (page turn);

2.3. Screen orientation.

Continued on next page.

3. Audible Controls:

3.1. Screen reader:

3.1.1. Speech rate.

3.2. Text to Speech (TTS):

3.2.1. Speech rate.

3.3. Simplification:

3.3.1. Read along;

3.3.2. Synonyms on demand;

4. Voice Controls:

4.1. Voice recognition.

It should be noted that overlaps can occur between the controls, for example, the use of the mobile device screen reader relates to both touch and audible controls. The screen reader requires the use of device gestures to move focus when navigating the user interface but it also requires audio controls such as being able to alter the speech rate of the screen reader.

The purpose of the analysis was to determine two outcomes: firstly, the areas where accessibility features were supported across the mainstream devices and mobile browsers; and, secondly, the areas that need to be addressed, such as simplification features that meet the accessibility requirements for dyslexic users. The Safari and Explorer mobile browsers were excluded because they were platform dependent. This is limiting, particularly for iOS users, but it was to remain in keeping with a technology neutral approach as specified by WCAG 2.0. If no API call was available, then a mapping to WCAG 2.0, UAAG 2.0 and the ETSI EG 203350 Human Factors (HF) guidelines was provided for future APIs to be developed and the expected accessibility outcomes.

6.3 Expert Review Two method

The ethics application for Expert Review Two was ERGO/FPSE/30291. In total 8 expert participants (n=8), 6 male and 2 female, agreed to take part in the expert review. 16 expert participants were initially invited to participate in an online survey using the University of Southampton's official data collection tool iSurvey. The expert participants

Chapter 6: Development of the instrument

were from relevant domains, namely: those working as accessibility or altformat consultants; specialists; developers; librarians; and publishers. They were from 10 HEI's, two academic publishers and one Non-Governmental Organisation (NGO). The NGO remains nameless to provide anonymity as per data protection requirements. Eight of the expert participants were unknown to the researcher. The link to the expert review on iSurvey was sent in separate emails to 16 participants on the 11th September 2017. The survey questions were not sent out with the email. If the experts were willing to take part in the online review they had to read both participant and consent information. The participants then had to check a box with the following wording:

- Please tick (check) this box to indicate that you have read and agree to both the participant and consent information.

iSurvey prevented the participants from proceeding until the check box had been selected. The review also required a password that was provided in the email sent out, to ensure that only the expert participants could take part. The email also stated that the review would take no longer than 15 -20 minutes of the expert participant's time. In addition to this, a link to useful further information about 13 native and online ereader applications that consider accessibility would be provided on completion of the survey. This served as an incentive to fill out the survey questionnaire. It should be noted that the list of ereader applications was updated after the academic and student use case walkthroughs and included the following four applications:

1. Easy Reader – Dolphin;
2. FBReader and PDF Plugin;
3. Go Read (RNIB Bookshare);
4. KNFB Reader (OCR Reader).

The participants were given one week to respond anonymously through iSurvey from the date they received the link. Data collection ceased on the 23th September 2017 at 11:59pm. The expert review contained information to be read, questions to be answered and simple checks of an HEI institute portal or publishers website based on the use of an online prototype. The expert email addresses were obtained from a secure and closed

external email list relevant to the area of investigation. One of the academic publishing companies provided written consent to take part in the survey.

Using iSurvey, the participants were able to respond to the review anonymously. No contact was made with the experts once they had completed the survey, other than the iSurvey automated response that the survey had been completed. The anonymised results were published online after the expert review but were removed on completion of the researcher's doctorate.

The stimuli given to the experts included an online questionnaire, with links to accessible information that could be downloaded, and a secure link to an online prototype and walkthrough. As with Expert Review One questionnaires were used because they were the most commonly implemented when undertaking evaluations relating to adaptive and adaptable interfaces (Van Velsen et al., 2008). The individual expert participants were required to answer questions in two sections on a semi structured online questionnaire. The questions related to:

1. Section 1: Demographics and expertise; and
2. Section 2: Six questions relating to the review of a prototype and walkthrough using a set of representative automatic BW success criteria for automated checks and user tasks.

In section one demographic data for gender and age range were gathered to provide a population sample. The age ranges were 18-29, 30-49, 50-64 and 65+ with the option where the participant could specify that they 'prefer not to say'.

What constituted an expert was determined by requiring the expert reviewers to answer closed ended questions. The first set of three questions required a Subjective Knowledge (SK) rating to be given. The second set of nine questions determined the actual experience of the participants. As with Expert Review One Brajnik et al state that providing actual expertise yields more useful information and enables results to have greater validity (Brajnik et al., 2011). The three subjective knowledge ratings were presented to the participant on a Likert scale (Likert, 1932) item where 1 was the lowest and 5 was the highest for each of the following questions:

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1. What is the level of your web accessibility knowledge? (Eg. Web content and the barriers faced by disabled people using the web).
2. What is the level of your mobile web accessibility knowledge? (Eg. Small screen content and responsive design).
3. What is the level of your mobile accessibility knowledge? (Eg. Device hardware and accessibility settings).

The nine questions that determined actual experience were as follows with set options:

1. Working as an accessibility: consultant, specialist, developer, librarian, publisher:
Less than two years, 2-5 years, 6-10 years, 11-15 years and 16+ years.
2. Tested more than 10 websites for accessibility in the last 6 months? Yes/No.
3. Tested more than 10 mobile applications for accessibility in the last 6 months?
Yes/No.
4. Tested more than 3 mobile browsers for accessibility in the last 6 months? Yes/No
5. Tested both the Android and iPhone mobile devices for accessibility in the last 6 months? Yes/No.
6. Have you used an ereader 'app' for reading academic electronic texts (etexts) on a smartphone in the last 6 months? Yes/No.
7. If yes, which format do you most regularly use? PDF, EPUB3, Both the same.
8. If PDF, and if available, do you use reflow? Yes/No.
9. Do you use Text to Speech (TTS)? Yes/No.

If an expert had less than two years' experience their results were excluded from the analysis. The questions were asked in order to determine the actual experience of the individual expert participants.

Section two was divided into two parts, the first part required individual experts to read through two lists that were provided, see Table 24 and Table 25. The second part required the individual experts to answer 11 questions. The purpose of section two was to identify key issues for mobile web accessibility. The checks indicated in Table 24 enabled an evaluation of an HEI library mobile web portal or academic publishers website based on the use of a prototype tool. The participants were also made aware that the Web Content Accessibility Guidelines (WCAG 2.0) were used throughout the review and

that only smartphones were being assessed. The expert participants were not expected to know all the aspects of the mobile web accessibility domain. Additional information (see Appendix H) was provided in the form of an accessible download if a more in depth understanding of the key issues for mobile web accessibility were required. List one related to automatic checks for a device, mobile browser and HEI or academic publisher's website see Table 24.

Table 24: List One - Automated checks for device, mobile browser, and HEI or academic publisher's website.

List One: Automated checks for device, mobile browser, and website.
Visual Controls: 1. High contrast can be altered. 2. Text and background colour or themes can be altered. 3. Margin width, line spacing, character spacing and full screen can be altered. 4. Text size, font typeface, left justify, text reflow and zoom/magnification can be altered.
Touch Controls: 1. Check that the use of portrait or landscape mode can be altered. 2. Check that screen reader focus can be moved through navigation elements.
Audible Controls: 1. Check that Text to Speech (TTS) and speech rate can be altered.
Speech Controls: 1. Check that speech recognition can be altered in search boxes and the mobile browser address bar.

The reason these this representative sample of the automatic BW success criteria was included was to provide an independent means of evaluating the instrument. For a more in depth version of the automated checks the participants were provided with a download link to an additional accessible document, see Appendix H.

Table 25: List Two: User tasks for discovery and download.

List Two: User tasks for discovery and download	
1. Search 1 and search 1 result(s)	Discovery: Search for and navigate to the institute learning platform (Google search box and google result links).
2. Institute authentication	Using a single sign in (such as Shibboleth or Athens) login to the institute library with username, password, and sign in button.
3. Institute library portal steps	Navigate through the library resources to the academic publisher's website.
4. Search 2 and search 2 result(s)	Through single sign in to search for and navigate to the journal paper preview link on the publishers website. Publishers need to ensure that the user is taken directly to the paper searched for and not a general journal page.
5. Preview paper abstract	Read preview paper abstract made available on the academic publishers website.
6. Read accessibility metadata prior to download.	Currently not available on vendors websites. The prototype provides a demonstration of this feature.
7. Search 2 result	Download: Select download link for journal paper on academic publisher's website.
8. Manage downloads	Navigate through website options for local device download or transfer to third party cloud storage.

List two related to the user tasks for discovery and download, see Table 25. Each of the automated checks in Table 24 needed to be undertaken for each of the user tasks in Table 25.

The online prototype and walkthrough were deliberately provided in case an expert participant did not have access to an HEI library mobile web portal or an academic publisher's website. The following secure link to the prototype and walkthrough was provided ([prototype and walkthrough](#))¹ and the participant was instructed to follow onscreen instructions. The prototype and walkthrough was designed to give the expert participant an overview of a process undertaken by an academic or student for discovery and download of an HEI etext.

For example, Figure 21- Figure 24 provide example screenshots of what the participant would see when viewing accessibility metadata made available on an academic publisher's website. It should be noted that this type of information is not currently provided by vendors but has been included in the prototype. Refer to Appendix H for the remaining 68 screenshots for both the prototype and the walkthrough.

The individual expert participants were instructed to tap either a red circle or the words '<previous>' or '<continue>' to progress through or go back to the previous screenshot in the prototype and walkthrough. The prototype and walkthrough screenshots were divided into two groups. The prototype focused on the ereading component whereas the walkthrough focused on navigating through the HEI library web portal or publishers website.

There was, however, an exception when producing the screenshots for the availability of accessibility metadata on the publisher's website. Since this is not currently available on vendors websites it was included in the prototype rather than as part of the walkthrough.

¹ <https://invis.io/7VD7CGCTR>

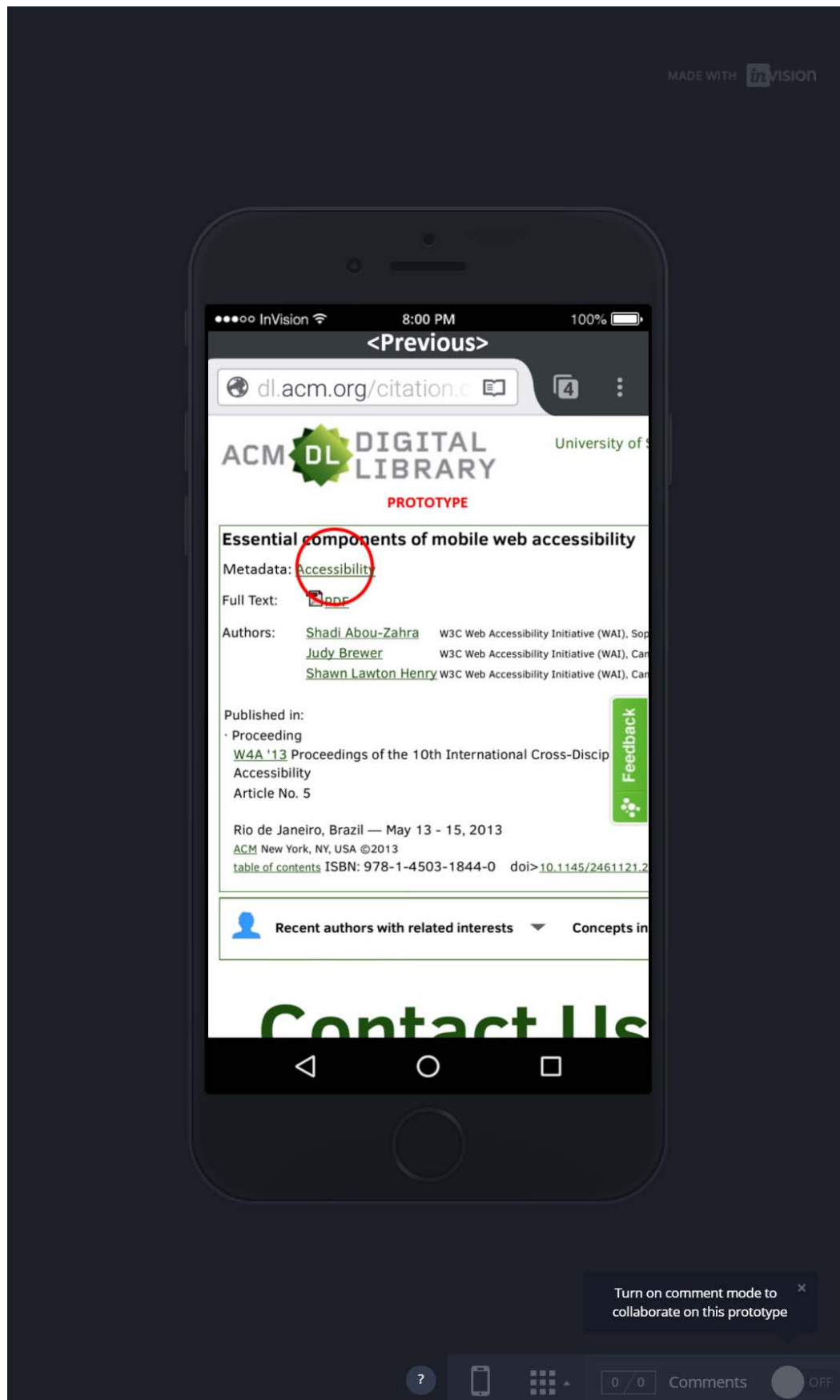


Figure 21: Accessibility metadata exposed on academic publisher's website.

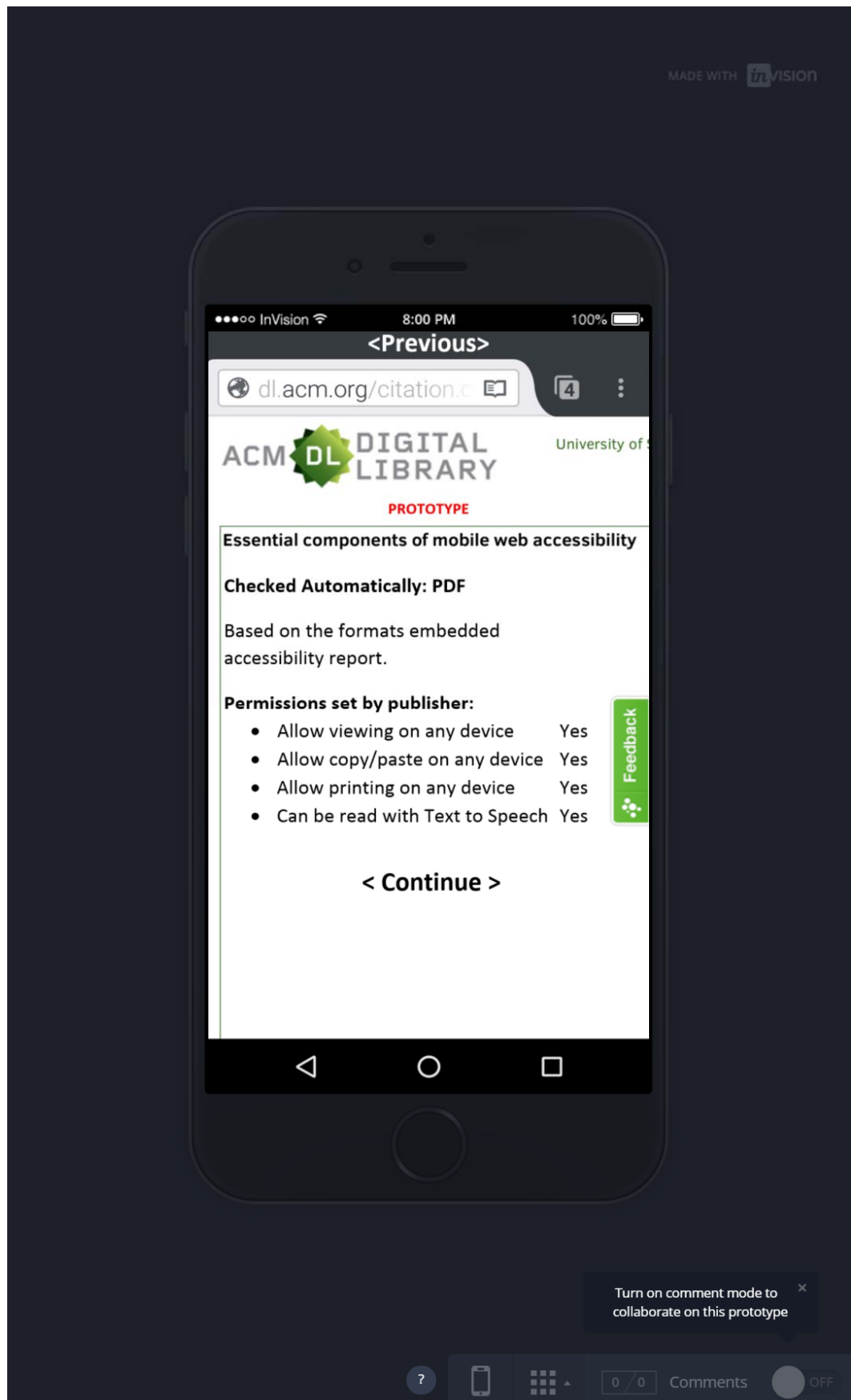


Figure 22: Accessibility metadata permissions set by the academic publisher.

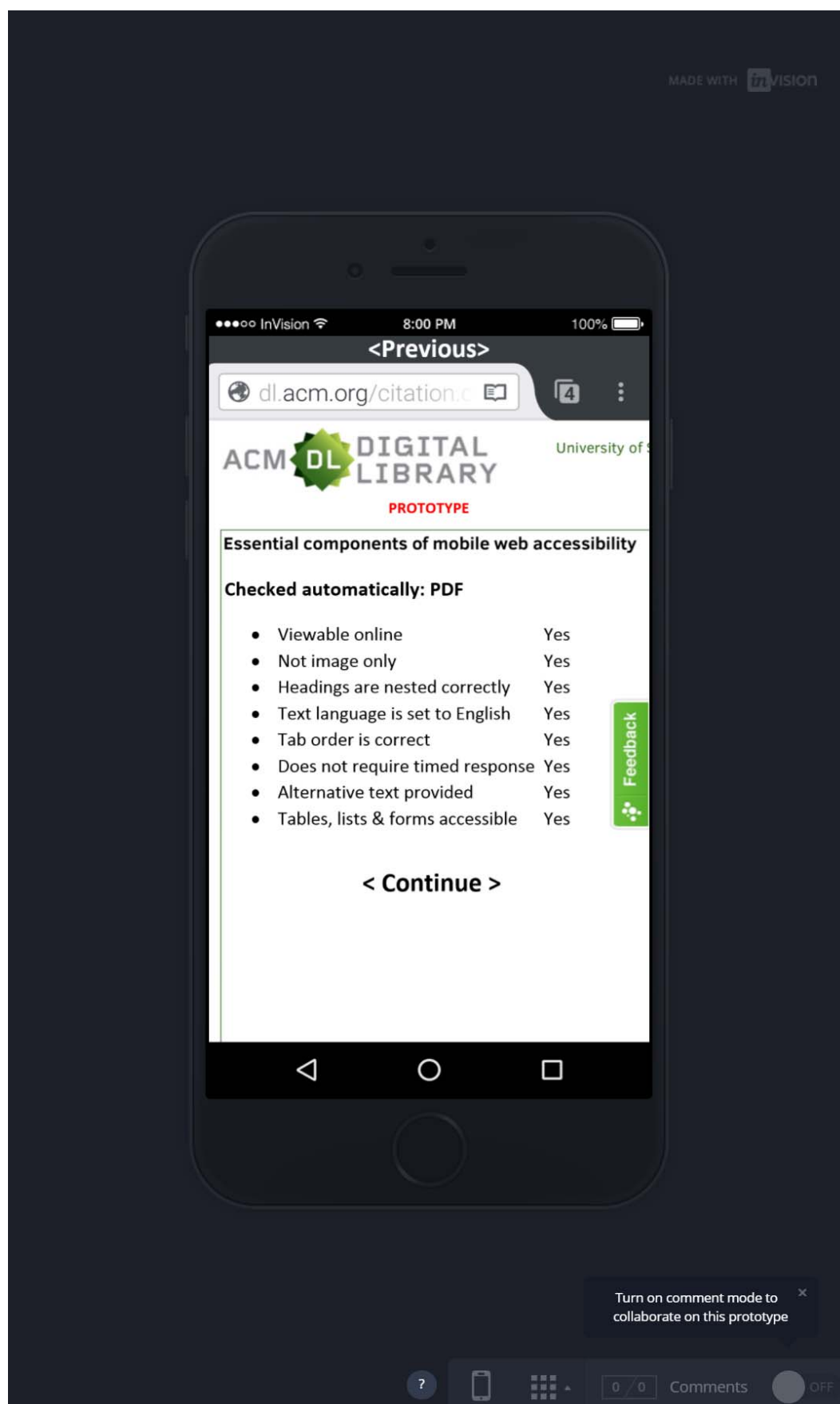


Figure 23: Accessibility metadata checked automatically by the academic publisher.

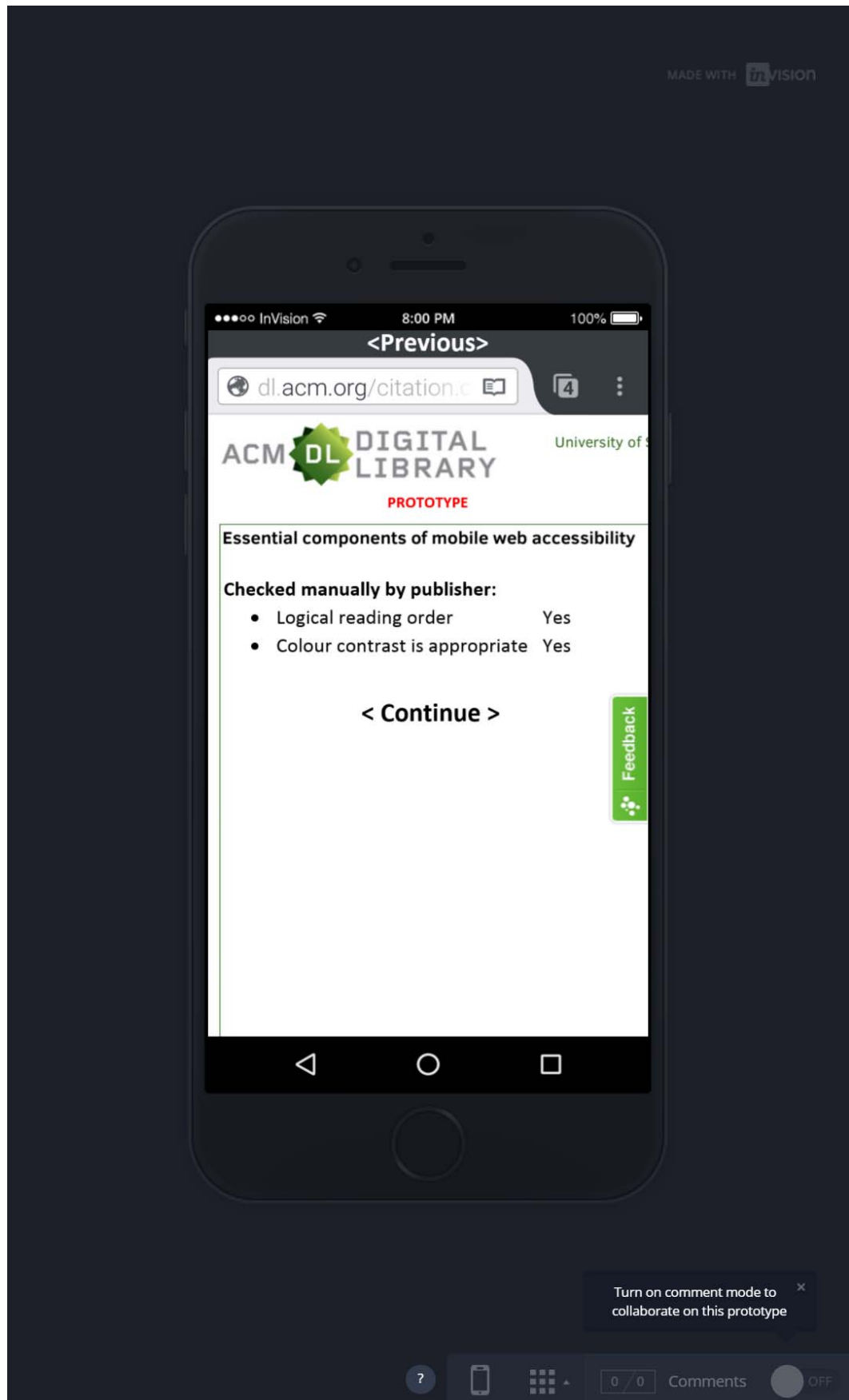


Figure 24: Accessibility metadata checked manually by the academic publisher.

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In the second part of section two the individual experts were required to answer 6 questions. For five of the questions the individual experts were required to provide qualitative comments briefly explaining their answers.

Prior to answering the questions the following statement was made:

'Important: If you are a publisher please answer question nine. If you are a librarian please answer question seven. It is also important to answer the remaining questions.

The following questions need to be answered with three perspectives in mind, namely: as the academic or student, the librarian, and the publisher. **Please note:** if you are from another profession please use the prototype as an example and answer only one of the questions seven or nine, with your publishers or librarians 'hat' on.

Based on the list of automated checks for user tasks (discovery and download) and the prototype tool:'

1. Can anything be improved? Yes, No, Not Sure
2. Please briefly explain your answer. In each case where an expert was required to explain their answer this was followed by a box for qualitative comments.
3. Can anything be removed? Yes, No, Not Sure
4. Please briefly explain your answer.
5. Has anything been overlooked? Yes, No, Not Sure
6. Please briefly explain your answer.
7. If you are a librarian it is important to answer this question. On a scale of 1 to 5 do you agree that the tasks 1 – 3 work on your institute's library portal?
Strongly disagree - 1 2 3 4 5 - Strongly agree.
8. Please briefly explain your answer.
9. If you are a publisher it is important to answer this question. On a scale of 1 to 5 do you agree that the tasks 4 -7 work on your publisher's website?
Strongly disagree - 1 2 3 4 5 - Strongly agree.
10. Please briefly explain your answer.

11. In your opinion what accessibility requirements are necessary for the mobile web accessibility of Higher Education electronic texts for print impairments? This was also followed by a box for qualitative comments by the individual experts.

Question seven was aimed specifically at HEI librarians; whereas question nine was aimed at academic publishers. There was, however, a caveat in that other specialists in the alt-format and accessibility sectors who were involved and were required to undertake the review from both a librarian and an academic publisher's perspective. This was permitted because the review of the heuristic walkthrough criteria, to be used for automatic evaluation, was easy to use on a web portal for an HEI library or that of an academic publisher's website. The BW success criteria included a list of automated checks for mobile devices, mobile browsers and websites. Since the questions were on an anonymous online survey social desirability bias, where the participant deliberately provides a response to present themselves favourably (Trewin et al., 2015), was reduced (Richman et al., 1999).

The combined outcome of chapter four and the development process indicated in chapter five led to the development of an instrument and metric that needed to be independently reviewed by individual experts. This was the reason why Expert Review Two had to be undertaken and formed the final aspect of triangulation. The instrument measures user tasks against physical and sensory controls. The user tasks relate to the steps undertaken by the print impaired user on an HEI library web portal to search for, find, download, navigate and read an etext on a mobile device. The physical and sensory controls, incorporate cognitive controls for dyslexia, and relate to the accessibility settings for mobile devices, ereader applications, mobile browsers and etext formats.

6.4 Chapter summary

Three methods were developed in this chapter in order to enable further testing of the instrument and to complete the framework. Firstly, by carefully searching standards specific to the PDF and EPUB3 it is possible to determine the availability of accessibility metadata in the form of tags. This is important because these tags enable the accessibility

Chapter 6: Development of the instrument

metadata to be programmatically detected by AT. This included the PDF standard BS ISO 3200-1:2008, the IDPF EPUB 3.0 accessibility standard and the ONIX code list 196.

Secondly, it was important to establish exactly which mobile device and mobile browser API libraries had to be searched to determine accessibility support. The reason for this was twofold, it would not only determine the availability of existing API accessibility support but would also identify areas for future API development. In providing a means to test both the accessibility metadata of the PDF and EPUB3 formats in tandem with the API accessibility support, the remaining components of the instrument had a means of being tested as to whether they were robust or not.

Finally, the method designed for Expert Review Two related to the use of a survey that determines if the automatic BW success criteria generated by the instrument would work on an HEI library web portal when used on a mobile device. The design of the survey involved the use of Likert scale items in order to evaluate the outcome when tests are undertaken.

This was taken forward by realising there was a distinction between human readable accessibility metadata within an ereader application and its exposure on an academic publisher's website. In addition to this the accessibility metadata tags that were identified aided the development of a proof of concept tool. This tool uses a web service to extract accessibility metadata from the PDF format. This corroborated that a PDF format could be automatically evaluated for this purpose and that a specification and wireframe for four stakeholder specific web applications and a web service were required. In doing so this completes the instrument enabling a mapping to take place for WCAG 2.0 success criteria. In addition to this, it enables the detection of device accessibility features through APIs available to the OS rather than attempting to determine device accessibility usage by on device testing through User Behaviour Analytics (UBA). UBA requires user permissions.

Chapter 7 The instrument results and discussion

This chapter provides the results for the testing stages that lead into the results for Expert Review Two, and this review is followed by a summary. The purpose of the evaluation of the instrument is not a validation of the metric but to complete the framework and find out if a prototype could be used. The instrument requires an independent means of evaluation through individual expert review. The results are then discussed with changes that occurred to the automatic mobile web accessibility evaluation framework that integrates the device. The limitations of the expert review evaluation are then covered and the chapter concludes with an overall summary.

7.1 Results

The test results included 16 mobile ereader applications that were analysed by OS and econtent format. 14 of these mobile ereader applications operate across the three main OS smartphone platforms at the time of writing, namely the Android, iOS and the Windows phone. 12 supported compatibility with the PDF format; whereas 14 of the ereader applications supported the EPUB3 format. Table 26 (continued on next page) provides a list of the accessibility metadata availability for PDF and EPUB3 formats, device and mobile browser accessibility settings.

Table 26: PDF Accessibility metadata tag findings based on examining BS ISO 3200-1:2008.

Accessibility Requirement	32000-1:2008	Metadata <tag>
1. Fast Web View	pg. 680	Linearized
2. Printing Allowed?	pg. 60 & 61, 65 & 66	Security Handler Key P & bit position 12
3. Content Copying for Accessibility Allowed?	pg. 60 & 61, 65 & 66	Security Handler Key P & bit position 5, 10
4. Accessibility report attached to document?	pg. 74, 81	EmbeddedFiles

Table 26 continued.		
Accessibility Requirement	32000-1:2008	Metadata <tag>
5. Accessibility permission flag is set	pg. 60 & 61, 65 & 66	Security Handler Key P & bit position 5, 10
6. Document is not image-only PDF (this was referred to as Reliable Encoding).	pg. 651	StandardEncoding, MacRomanEncoding, WinAnsiEncoding, PDFDocEncoding, MacExpertEncoding
7. Document is tagged PDF	pg.74 & 556	MarkInfo Marked
8. Enable Assistive Technology Support	pg. 610-616	Lang, Alt, ActualText, E property
9. Document Structure Used for Tab Order	pg. 553	MP, DP, BMC, BDC, EMC
10. Document Structure Provides Logical Reading Order	pg. 557, pg. 577-578	ParentTree, Ordering
11. Text language specified	pg. 74, 611	Lang (Search text string for the ISO 639 code for the language in the Language field.)
12. Document title showing in title bar	pg. 363	DisplayDocTitle
13. Bookmarks present in large documents	pg. 59, 61, 74, 367, 374	Outlines, Bit Position 11 and PageLabels
14. Document has appropriate colour contrast	pg. 74, 81	*Read the embedded accessibility report? .pdf.accreport.html
15. Custom Properties (eg. Publishers Accessibility Contact Details)	PDFX Namespace	<pdfx:Name>Value</pdfx:N ame>

Table 26 continued.		
Accessibility Requirement	32000-1:2008	Metadata <tag>
16. PDF Version	pg. 73	Version
17. Embedded Fonts	pg. 288-290	FontFile
18. Creation Date	pg. 550	CreationDate
19. Copyright Status	pg. 28 (XMP Specification Part 1)	<xmpRights:Marked>True</xmpRights:Marked>
20. PDF File Size	N/A	<?php Echo filesize("test.txt"); ?>

In terms of determining PDF and EPUB3 accessibility metadata programmatically 20 accessibility tags were identified for the PDF format. In addition to this an additional 20 tags were found for PDF ereading feature accessibility metadata, see Table 27, such as background and text colour.

Table 27: PDF ereading feature accessibility metadata. Continued on next page.

Accessibility Requirement	32000-1:2008	Metadata <tag>
1. Page Layout	pg.73	PageLayout
2. Background Colour	pg.83, 595, 598	BackgroundColor
3. Line Height	pg.595, 604	LineHeight
4. Text Decoration Colour	pg.595, 604	TextDecorationColor
5. Text Decoration Type	pg.595, 605	TextDecorationType
6. Text Align	pg.601	TextAlign
7. Font Family	pg.580	FontFamily
8. Generic Font Family	pg.580	GenericFontFamily

Table 27 continued.		
Accessibility Requirement	32000-1:2008	Metadata <tag>
9. Font Size	pg.580	FontSize
10. Font Style	pg.580	FontStyle
11. Table of Contents	pg.584	TOC
12. Index	pg.584	Index
13. Headings	pg.585	H, H1-H6
14. Paragraph	pg.585	P
15. Lists	pg.585	L, LI
16. Label	pg.586	Lbl
17. Link	pg.588	Link
18. Formula	pg.592	Formula*
19. Zoom	pg.232	Zoom
20. Full Screen	pg.74	PageMode, FullScreen

Seven accessibility metadata tags were discovered, see Table 28, when investigating the IDPF EPUB3 standard for accessibility metadata (IDPF, 2017).

Table 28: IDPF EPUB 3.0 Standard findings. Continued on next page.

Accessibility Requirement	https://Schema.org/	Metadata <tag>
Access Mode	https://goo.gl/yHI6x2	accessMode
Accessibility Feature	https://goo.gl/5fk5sc	accessibilityFeature
Accessibility Hazard	https://goo.gl/HiyqLv	accessibilityHazard
Accessibility Summary	https://goo.gl/ciKssx	accessibilitySummary

Table 28 continued.		
Accessibility Requirement	https://Schema.org/	Metadata <tag>
Access Mode Sufficient	https://goo.gl/gvr0Ur	accessModeSufficient
Accessibility API	https://goo.gl/94bmol	accessibilityAPI
Accessibility Control	https://goo.gl/1N7wWx	accessibilityControl

Alongside this, an additional 19 tags were identified for the ONIX code list 196, see Table 29 that specifically relate to the accessibility of epublications (EDItEUR, 2018).

Table 29: ONIX Code list 196 E-publication accessibility details. Continued on next page.

Accessibility Requirement	Onix for Books Guidelines	Metadata <tag>
Accessibility Summary	https://tinyurl.com/y4acng44	00 <ProductFormFeatureDescription>
No reading system accessibility options disabled	https://tinyurl.com/y4acng44	10 (Exception to ePub3)
Table of contents navigation	https://tinyurl.com/y4acng44	11
Index navigation	https://tinyurl.com/y4acng44	12
Reading order	https://tinyurl.com/y4acng44	13
Short alternative descriptions	https://tinyurl.com/y4acng44	14
Full alternative descriptions	https://tinyurl.com/y4acng44	15

Table 29 continued.		
Accessibility Requirement	Onix for Books Guidelines	Metadata <tag>
Visualised data also available as non-graphical data	https://tinyurl.com/y4acng44	16
Accessible math content	https://tinyurl.com/y4acng44	17
Accessible chem content	https://tinyurl.com/y4acng44	18
Print-equivalent page numbering	https://tinyurl.com/y4acng44	19
Synchronised pre-recorded audio	https://tinyurl.com/y4acng44	20
Text-to-speech hinting provided	https://tinyurl.com/y4acng44	21
Language tagging provided	https://tinyurl.com/y4acng44	22
Compliance web page for detailed accessibility information	https://tinyurl.com/y4acng44	94
Trusted intermediary's web page for detailed accessibility information	https://tinyurl.com/y4acng44	95
Publisher's web page for detailed accessibility information	https://tinyurl.com/y4acng44	96
Compatibility tested	https://tinyurl.com/y4acng44	97

Table 29 continued.		
Accessibility Requirement	Onix for Books Guidelines	Metadata <tag>
Trusted Intermediary contact	https://tinyurl.com/y4acng44	98
Publisher contact for further accessibility information	https://tinyurl.com/y4acng44	99

Since it was established that for both the PDF and EPUB3 formats that accessibility metadata tags were available for extraction it was then necessary to determine the API accessibility support for both the mobile device and mobile browsers.

The mainstream smartphone device OS platforms, Android, iOS and Windows were analysed in conjunction with three cross platform mobile browsers, Chrome, Firefox and Opera to determine device and mobile browser API accessibility support.

23 device and mobile browser accessibility features, see Table 30, were assessed within the four physical and sensory control categories that incorporate simplification, a key accessibility requirement for dyslexia.

Table 30: Device and mobile browser API accessibility support. Continued on next page.

Control	Device	Android mobile browser	Total (6 max)	Comment
	iOS, Android, Windows	Chrome, Firefox, Opera		
Visual – Themes & Styles				
1. High Contrast	3	0	3	Windows (High Contrast) iOS/Android (Colour Inversion)
2. Brightness	3	1	4	
3. Text Colour	3	3	6	
4. Background Colour	3	3	6	
5. Colour Correction/Filter	1	0	1	Does not explicitly refer to.
6. Pre-set Text Colour & Background Colour (Themes)	1	0	1	Does not explicitly refer to.
7. Font Family/Typeface	3	3	6	

Table 30 continued.				
Control	Device	Android mobile browser	Total (6 max)	Comment
	iOS, Android, Windows	Chrome, Firefox, Opera		
Visual control - Layout (White Space) & Declutter:				
8. Margin Spacing	3	3	6	
9. Line Spacing	3	3	6	
10. Character/Letter Spacing	3	3	6	
11. Left Justification (Ragged Right)	3	3	6	Refers to text alignment. Does not explicitly refer to left justification.
12. Full Screen	3	2	5	The full screen API has been discontinued by W3C (https://goo.gl/cBC3Ha).
Visual control – resizing:				
13. Text/Font Size	3	3	6	
14. Zoom/Magnification	3	3	6	
15. Reflow/Text or Word Wrap/Overflow Wrap/Thrashing	2	3	5	

Table 30 continued.				
Control	Device	Android mobile browser	Total (6 max)	Comment
	iOS, Android, Windows	Chrome, Firefox, Opera		
Touch control:				
16. Device Gestures	3	3	6	
17. Hard Volume Button (Page Turn)	2	0	2	
18. Screen Orientation	3	2	5	
Audible control:				
19. Screen Reader	2	3	5	
20. Text to Speech (TTS)	3	0	3	
Audible control - Simplification				
21. Read along	0	0	0	The APIs do not explicitly refer to read along. Available in ereader applications through media queries.
22. Synonyms on demand	0	0	0	The APIs do not explicitly refer to this. Available in ereader applications, such as the DysWebxia Reader (Rello, 2014).

Table 30 continued.				
Control	Device	Android mobile browser	Total (6 max)	Comment
	iOS, Android, Windows	Chrome, Firefox, Opera		
Voice control:				
23. Voice Recognition	3	1	4	Voice recognition is more about recognising a voice for actions on a device whereas speech recognition is about recognising what is said so it can be converted into text.

Out of the 23 accessibility features, 10 were supported across all three OS platforms and the cross platform mobile browsers indicated by the total number six. They included:

1. Text colour;
2. Background colour;
3. Font family/typeface;
4. Margin spacing;
5. Line spacing;
6. Character/letter spacing;
7. Left justification (ragged right);
8. Text/font size;
9. Zoom/magnification;
10. Device gestures.

Chapter 7: The instrument results and discussion

Since this was the case, it indicates that although API accessibility support is available it is limited. The combined results of the PDF, EPUB3, API accessibility support, and the results of the ereader application from Chapter 5 enabled Expert Review Two to be undertaken. Expert Review Two had 8 expert participants (n=8), 6 male and 2 female, who agreed to take part in the review. The demographic and expertise data (see Table 31) and the qualitative comments for Expert Review Two follow.

Table 31: Demographics and expertise data for Expert Review Two.

Continued on next page.

Gender	Male	Female	Total
	6	2	8

Age Range	18-29	30-49	50-64	65+	Total
		5	1	2	8

Web accessibility knowledge (Likert scale rating)	1	2	3	4	5	Total
			1	5	2	8

Mobile web accessibility knowledge (Likert scale rating)	1	2	3	4	5	Total
			3	5		8

Mobile accessibility knowledge (Likert scale rating)	1	2	3	4	5	Total
			3	5		8

Worked as consultant/specialist	Less than 2 years	2-5 years	6-10 years	11-15 years	16+	Total
			3	3	2	8

Table 31 continued.			
Response	Yes	No	Total
Tested +10 websites (last 6 months)?	5	3	8
10+ mobile applications (last 6 months)?	2	6	8
3+ mobile browsers (last 6 months)?		8	8
Both iOS & Android (last 6 months)?	5	3	8
Ereader app reading academic etexts (last 6 months)?	5	3	8

	PDF	EPUB3	Both the same	Total
Which format?	4		3	7
	Yes	No	Total	
If PDF, and if available use reflow?	3	4	7	
Use TTS?	5	3	8	

One expert participant did not answer the question: 'If yes, which format do you most regularly use'? Based on a Likert scale rating from 1 to 5, there was only one participant who provided a neutral score about their expertise in terms of web accessibility. However, three expert participants for both mobile web accessibility and mobile accessibility provided neutral scores.

The overall experience of the individual experts ranged from 6 to over 16 years. In response, in the last six months, five participants had tested over 10 websites for accessibility. Two participants had tested over 10 mobile applications for accessibility. No participants had tested over three mobile browsers for accessibility. Five participants had tested both the iOS and Android platforms. One expert participant did not answer the question: 'If yes, which format do you most regularly use?' Four participants, out of seven, stated that they use the PDF format most regularly; whereas three participants out

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of seven said that their usage was the same for both formats. Three participants, out of seven, had used reflow when reading a PDF; whereas five, out of eight participants, had used TTS.

In terms of the question for the prototype and the automatic BW success criteria working on the HEI library web portal (Q3.10) two of the expert reviewers in Table 32, with over 16 year's experience, agreed and one participant with 11 – 15 years experience agreed. The participant who strongly agreed had 6 – 10 years' experience.

Table 32: Participant expertise against Likert scale score response.

No.	Participant ID	Expertise in years	Q3.10	Q3.12
1	2475816	16+	4	4
2	2476468	16+	4	-
3	2490068	6 to 10	4	-
4	2490339	11 to 15	3	-
5	2495604	11 to 15	4	-
6	2505924	6 to 10	3	3
7	2525517	6 to 10	5	5
8	2543596	11 to 15	-	5

In terms of the question for the prototype and the automatic BW success criteria working on the publisher's website (Q3.12) one expert participant agreed and two expert participants strongly agreed out of a total of 8 participants. The questionnaire required six questions to be answered, three of those questions determined whether anything in the survey could be improved, removed or had been overlooked. One question required the expert evaluators to provide their opinion on what accessibility requirements were necessary for the mobile web accessibility of HE etexts for those with print impairments. See Table 33 it continues over the next 12 pages.

Table 33: Expert Review Two responses to the questionnaire, prototype and walkthrough.

Participant	Survey question	Check box response	Comment
ID 2475816	Can anything be improved?	Not Sure	Maybe need to finish the list with something that tells the user whether the document is accessible or needs work to make it accessible.
	Can anything be removed?	No	If anything you may need to add alternatives where the portals are found to be different to your example.
	Has anything been overlooked?	Not Sure	I have not looked at all the portals available or aggregators.
	On a scale of 1 to 5 do you agree that the tasks 1 - 3 work on your institute's library portal?	4	
	On a scale of 1 to 5 do you agree that the tasks 4 - 7 work on your publisher's website?	4	
	In your opinion what accessibility requirements are necessary for the mobile web accessibility of Higher Education (HE) electronic texts for print impairments?	I feel there needs to be a bridging of the gap between the AT offered on mobile web applications the digital accessibility offered by publishers with an increase in metadata as well as an understanding about what makes an etext accessible.	

Table 33 continued.			
Participant	Survey question	Check box response	Comment
ID 2476468	Can anything be improved?	Not sure	Prototype didn't allow : Touch Controls: Check portrait/landscape mode can be altered Check screen reader focus can be moved Speech Controls Check SR can be altered ... what does altered mean?
	Can anything be removed?	No	
	Has anything been overlooked?	Not sure	
	On a scale of 1 to 5 do you agree that the tasks 1 - 3 work on your institute's library portal?	4	Seem to fit OK
	On a scale of 1 to 5 do you agree that the tasks 4 - 7 work on your publisher's website?	No answer	No answer
	In your opinion what accessibility requirements are necessary for the mobile web accessibility of HE electronic texts for print impairments?	No answer	

Participant ID 2476468 did not provide an answer for the final question asking their opinion about the accessibility requirements that are necessary for the mobile web accessibility of HE electronic texts for print impairments.

Table 33 continued.			
Participant	Survey question	Check box response	Comment
ID 2490068	Can anything be improved?	No	I think it is quite complete
	Can anything be removed?	No	
	Has anything been overlooked?	No	
	On a scale of 1 to 5 do you agree that the tasks 1 - 3 work on your institute's library portal?	4	
	On a scale of 1 to 5 do you agree that the tasks 4 - 7 work on your publisher's website?	No answer	No answer
	In your opinion what accessibility requirements are necessary for the mobile web accessibility of HE electronic texts for print impairments?	There are two requirements: The portal of the institute must be accessible and the texts provided by the portal must also be accessible. In my opinion an accessible portal is easier to create and to maintain. Text is provided mostly in PDF form and created by many different persons or companies. Some of them are aware of accessibility and provide tagged accessible pdfs. Most of them don't.	

Table 33 continued.			
Participant	Survey question	Check box response	Comment
ID 2490339	Can anything be improved?	Not sure	Appears to be redundancy with three buttons (Aa, Tt and adjacent paragraph button) seeming to do the same thing. Also potential inconsistency - at Sussed example the Access options were an orange blob bottom right but didn't appear on all pages. Once we got to Accessibility Tools link a different set of options appeared.
	Can anything be removed?	Yes	I assume we're talking about the Accessibility Tools prototype at this stage? Or the Walkthrough? Making assumption of former, I'd have readability options all hit from a single button - maybe paragraph icon with Tt on top of it rather than three separate buttons.
	Has anything been overlooked?	Not sure	Assume talking about Accessibility tools? Ensure colour changes don't interfere with icon distinctiveness - eg in demo the Yellow text on Black makes the two Aa icons look identical even though they do different things.

Table 33 continued.			
Participant	Survey question	Check box response	Comment
ID 2490339 (continued)	On a scale of 1 to 5 do you agree that the tasks 1 - 3 work on your institute's library portal?	3	What do you mean - they are the right three task descriptions? They're all accessible on current system or they worked on the walkthrough demo?
	On a scale of 1 to 5 do you agree that the tasks 4 - 7 work on your publisher's website?	No answer	No answer
	In your opinion what accessibility requirements are necessary for the mobile web accessibility of HE electronic texts for print impairments?	Magnification, reflow, clear navigation functionality, colour change and TTS/screenreader OS compatibility are essential. Breadcrumb trails could help with navigation. Bookmarking and annotation are potentially really important but the latter requires export ability.	

Continues on next page.

Table 33 continued.			
Participant	Survey question	Check box response	Comment
ID 2495604	Can anything be improved?	Yes	As a person looking at how useful this would be for users of a library service, I think the menu options and automatic checks are described using too much technical language (e.g. headings are nested correctly, tab order is correct). I am concerned about my users functionality, not the technical description of the accessibility specification. For example I may have student X who can't use a mouse but can use a touch screen or keyboard. How can I tell from this list if this will? In the readability settings I think Margin Width is difficult to understand. Margin width "wide" results in a shorter line length. I like the kindle UI that shows me a representation of this. Similar left / justified / right have standard icons that can be used and are easier for those who confuse left and right.
	Can anything be removed?	Yes	I am not sure how much character spacing is required, if a good selection of fonts are available (as these have different character spacing).

Table 33 continued.			
Participant	Survey question	Check box response	Comment
ID 2495604 (continued)	Has anything been overlooked?	Yes	I would like to know when I download a publication if there are any restrictions on what apps I can open it in. Also "allow copy/paste on any device" - there are often restrictions on how much can be copied due to DRM. That information should be available. "Can be read with Text to speech" is a very wide statement. Does this mean assistive technologies that use the accessibility API to grab the text and read the structure or any clipboard reader?
	On a scale of 1 to 5 do you agree that the tasks 1 - 3 work on your institute's library portal?	4	I think having some kind of accessibility rating and built in accessibility tools that work consistently over all ebook providers and publishers will benefit students and library users. At the moment they can be put off using ebooks as they don't know what experience they will have (and they assume one poor experience will be repeated).
	On a scale of 1 to 5 do you agree that the tasks 4 - 7 work on your publisher's website?	No answer	No answer

Table 33 continued.		
Participant	Survey question	Comment
ID 2495604 (continued)	In your opinion what accessibility requirements are necessary for the mobile web accessibility of HE electronic texts for print impairments?	I think I have answered this in my comments above by primarily: - consist information in one library site. IE (Internet Explorer) it's not good 2 publishers adopting 2 different accessibility rating scales - it has to be understandable to the end user (student and academic), the librarian as well as of value to the person paying for it. Why would this save me money? Is it going to reduce the amount of alt-format requests my library is going to have to process - the interface should use familiar icons and relate to what readers know. Most of them don't know what "accessibility" refers to but they may need a larger font because they can't see the text well on a small screen. Use terms that are not just for the disability/accessibility world.

Continued on next page.

Table 33 continued.			
Participant	Survey question	Check box response	Comment
ID 2505924	Can anything be improved?	Not sure	I think this is a very comprehensive list of the key things. Clearly you could be much more granular but we then run the risk of asking too much and people will do nothing.
	Can anything be removed?	No	I think the balance here is great and captures the deal breakers.
	Has anything been overlooked?	Not sure	I would add to the statement: Check that screen reader focus can be moved through navigation elements - that navigation can be achieved using key headings to improve navigation speed and efficiency - particularly when using screen readers.
	On a scale of 1 to 5 do you agree that the tasks 1 - 3 work on your institute's library portal?	3	Much better using a desktop pc than a mobile device. Some of this also comes down to user design elements such as Plain English, not crowding pages, clear structure and page hierarchies.
	On a scale of 1 to 5 do you agree that the tasks 4 - 7 work on your publisher's website?	3	

Table 33 continued.		
Participant	Survey question	Comment
ID 2505924 (continued)	In your opinion what accessibility requirements are necessary for the mobile web accessibility of HE electronic texts for print impairments?	1. Text to speech. 2. Navigable structure 3. Reflowable 4. Able to be tailored e.g. font, contrast etc.

Continued on next page.

Table 33 continued.			
Participant	Survey question	Check box response	Comment
ID 2525517	Can anything be improved?	Yes	Check that screen reader focus can be moved through navigation elements. I think this should somehow be renamed, as not only the screen reader moves the focus but also switch access scanning programs.
	Can anything be removed?	No	The list seems fairly complete.
	Has anything been overlooked?	Yes	Switch-access control is not mentioned
	On a scale of 1 to 5 do you agree that the tasks 1 - 3 work on your institute's library portal?	5	I think the list is quite complete.
	On a scale of 1 to 5 do you agree that the tasks 4 - 7 work on your publisher's website?	5	I think the list is quite complete.
	In your opinion what accessibility requirements are necessary for the mobile web accessibility of HE electronic texts for print impairments?	The requirements are a combination of an accessible web-page where students are able to search for documents and accessible documents in multiple forms to suit the different needs of students.	

Table 33 continued.			
Participant	Survey question	Check box response	Comment
ID 2543596	Can anything be improved?	Not sure	The prototype appears to be comprehensive and useful. It would be interesting to hear more about the results that are gathered from a test of a website. Is the website scored? Are the test results open to interpretation by the tester?
	Can anything be removed?	No	I do not think anything needs to be removed
	Has anything been overlooked?	Yes	I didn't see a reference to the help pages on the platform. Is it within scope to highlight that a platform has an accessibility help page? This can be a useful resource for users.
	On a scale of 1 to 5 do you agree that the tasks 1 - 3 work on your institute's library portal?	No answer	No answer
	On a scale of 1 to 5 do you agree that the tasks 4 - 7 work on your publisher's website?	5	Task 4: 5 Task 5: 5 Task 6: 1 Task 7: 5

Table 33 continued.		
Participant	Survey question	Comment
ID 2543596 (continued)	In your opinion what accessibility requirements are necessary for the mobile web accessibility of HE electronic texts for print impairments?	Journal articles on our Journals platform and Books on our <redacted to anonymise> platform can be searched for on article and chapter levels. Abstracts are freely available. Full-text content is available to those institutions with access. Chapters and articles are downloadable in PDF form (one click). The PDF content is built directly from the original XML, improving the accessibility functions.

The questionnaire also included two key questions relating to the use of the instrument automatic BW success criteria to evaluate a prototype and walkthrough for an HEI library web portal (Q3.10) and academic publisher's website (Q3.12) on a mobile device.

Although eight expert reviewers undertook the survey, seven answered the question relating to an HEI web portal. This was the case even though a request was made on the survey to answer the required questions because this could adversely affect the results, particularly with small sample sizes.

This fell below the minimum requirement specified by published research findings for heuristic evaluation. Nielsen and Landauer stipulate an approximate value of 10 expert participants before diminishing returns are evident (Nielsen and Landauer, 1993); whereas Hwang and Salvendy maintain that 8 evaluators are the minimum requirement (Hwang and Salvendy, 2010). During the survey, 5 expert reviewers, out of the seven participants, agreed (4 reviewers) or strongly agreed (1 reviewer) that the prototype and heuristic walkthrough criteria would work on an HEI library web portal. However, two participants, provided neutral scores for the same question. One expert participant did not answer the question, perhaps because they did not see the statement previously referred to, also adversely affecting the results.

7.1.1 Summary of Expert Review Two results

Expert Review Two, evaluated an abridged version of the instrument. The reason for this was to reduce the amount of time taken by the experts to undertake the review and to encourage participation. Eight individual expert reviewers were involved in the survey (n=8). In the nine tests, having less than 8 participants answer the required questions adversely affected the scoring. The majority of the expert participants had evaluated the iOS and Android devices in the last six months and also used an ereader application for reading academic etexts. Three out of seven participants made use of both the PDF and EPUB3 format when reading academic etexts. One expert participant did not answer the question: if yes, which format do you most regularly use? The majority of the expert reviewers had used TTS but only three out of seven participants had used reflow when reading a PDF. This may indicate that the availability of reflow in Adobe Acrobat Reader needs to be highlighted by Adobe in their mainstream marketing campaigns.

The overall remarks made by the individual experts for the second review were encouraging and indicated that the research was heading in the right direction. However, having the majority of the individual experts agree, rather than strongly agree, would seem to suggest that further analysis is required.

7.2 Discussion

Undertaking the careful searches through the PDF standard BS ISO 3200-1:2008, the IDPF EPUB 3.0 standard and the ONIX Codelist 196 revealed important information relating to accessibility. The econtent component of the framework could be subsumed into the econtent format component, as indicated in Figure 25. In doing so it was also realised that the Metadata component of the framework could also be included in the econtent format component. For example, the headings available within the PDF, shown on page 585 of BS ISO 3200-1:2008, indicate that the tags H1 – H6 can be programmatically determined. If a screen reader user is navigating through a document tagged correctly for accessibility they will hear the semantic structure, in this case headings, read aloud. Whereas the AT detects that the tags are available programmatically.

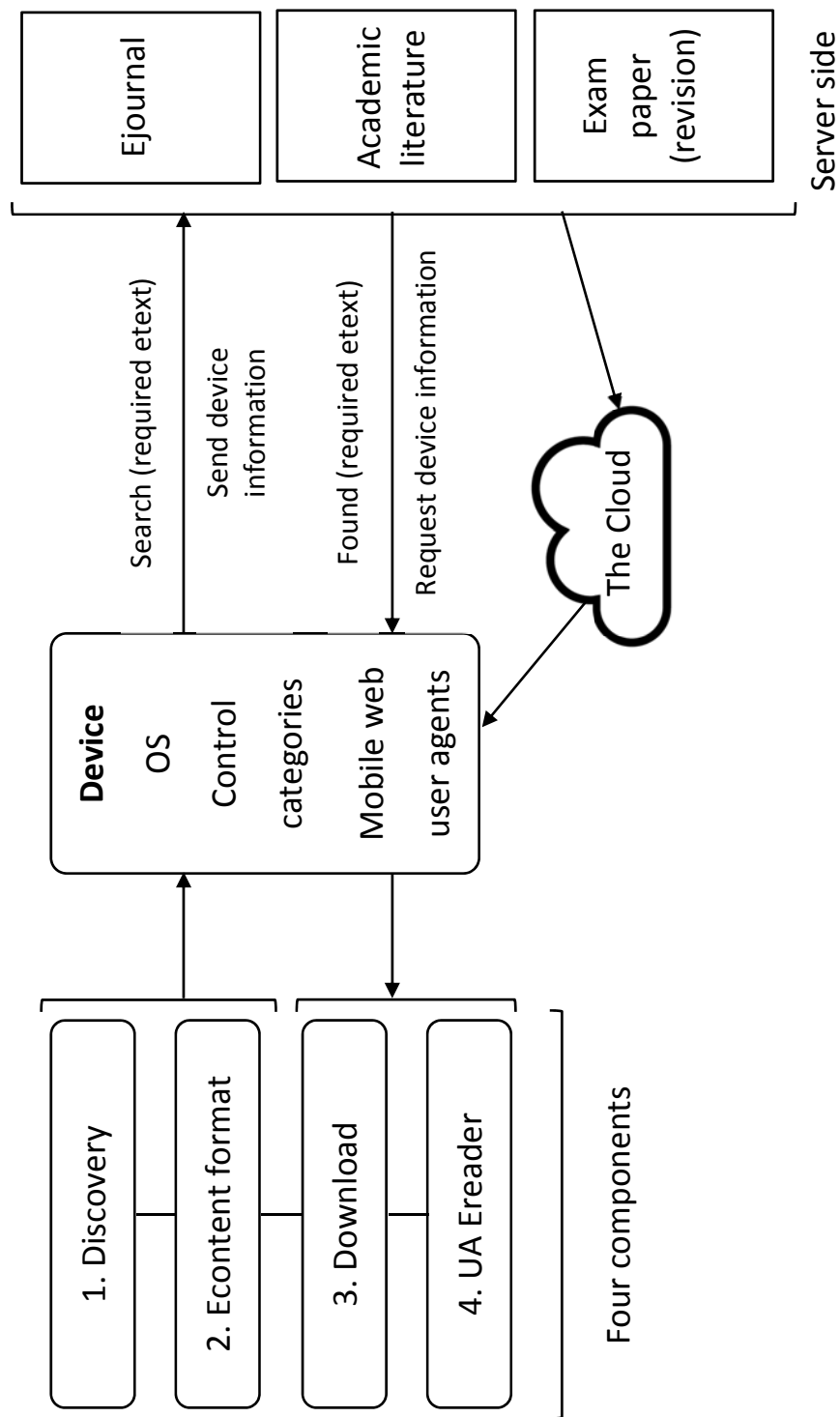


Figure 25: Updated automatic mobile web accessibility evaluation framework, integrating the device.

Since these tags were identical to both formats it warranted inclusion in the final instrument. There is a caveat, however, in that both of these tags require intervention on the part of the academic publisher and the academic aggregator. Having said that though an automated accessibility metadata extraction tool serves as a means of automatic Meta

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accessibility evaluation. In that it does not require an accessibility evaluation per se rather that it determines to what extent the academic publisher and academic aggregator have undertaken accessibility checks. This approach also does not rely on an accessibility summary or for an accessibility report to be provided.

Table 34: User tasks mapped to the updated framework components.

Discovery (includes search metadata)	Econtent format (includes format metadata)		Download	UA Ereader
	PDF (Example)	EPUB3 (Example)		
1. Search & search result (Google). 2. HEI library authentication (Login). 3. HEI web portal steps/search. 4. Academic publishers website steps/search/preview paper abstract/view accessibility metadata prior to download.	1. Fast web view. 2. Accessibility permission flag is set. 3. Accessibility report attached to document. 4. Document is tagged PDF. Includes navigation through headings (eg. H1 – H6). 5. Custom properties.	1. IDPF: Accessibility Summary (eg. contains MathML). 2. Onix Code 10 No reading system accessibility options disabled. 3. Onix Code 99: Publisher contact for further accessibility information.	1. Search result. Dialogue: 2. Manage downloads (includes DRM protected formats). 3. Third party storage	1. Authentication/synchronisation. 2. View Format Metadata in UA. 3. Help. 4. Import etext, Library (etext Shelf) & Library Search. 5. Manage Local Downloads & Third Party Storage access within the UA. 6. Plugin Usage. 7. Document View & Screen Orientation. 8. Manage Bookmarks & Links Menu. 9. Progression & Lookup. 10. Search etext.

Another feature of the PDF is that it can be viewed online within a web browser and this is determined by the accessibility metadata tag 'Linearization' referred to as fast web view. Caution is advised, however, according to BS ISO 3200-1:2008 (page 675) that an incremental update to a linearised PDF requires the entire file to be reprocessed.

Table 34 indicates how the econtent component was subsumed by including it in the PDF document tagged for accessibility. Since these are accessibility metadata tags this also demonstrates how the metadata component of the original framework was incorporated into the econtent format component.

The outcome of the instrument was over 400 mobile web accessibility automatic BW success criteria. These were based on the analysis of user tasks, relating to the four updated framework components, against physical and sensory control categories that incorporated issues arising for dyslexia (see Table 35 fold out). The full version that includes comments can be found in: N.E. (2019) Dataset for: Automatically evaluating the mobile web accessibility of Higher Education electronic texts for print impairments. University of Southampton doi: 10.5258/SOTON/D1064 [Dataset] under 'INSTRUMENTEcontentSubsumedFINAL2019.xlsx'. The automatic BW success criteria was taken forward by informing the writing of a specification and designing a wireframe for a mobile web accessibility evaluation tool. In order to ensure the specification and wireframe was heading in the right direction a prototype and walkthrough was created using the automatic BW success criteria for use in Expert Review Two.

If HEI library procurement specify that they are using a mobile web accessibility evaluation tool and that it is checking for both an accessibility summary and an accessibility report this places the onus of specific tag usage on external parties. In particular the academic publisher and the academic aggregators. In addition to this, this type of Meta evaluation also automatically exposes if manual tests have been undertaken on the format by the aforementioned stakeholders.

Typical automatic accessibility evaluation tools, for example when testing a PDF, cannot determine the reading order of a document or whether it has appropriate colour contrast. If, however, an academic publisher or academic aggregator, has checked the reading order or colour contrast of the document and specifies this in the accessibility

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metadata this information can be exposed automatically in two ways. It can be made humanly readable on either or both the academic publishers website or within the academic or students web application.

For example, the Bluefire Reader application has been highlighted, at the time of writing, as being the only ereader application that exposes the copy and paste permissions for text and whether the format can be opened on any device. Subsequent to this it was found that the Infinity Reader application provided print equivalent page numbering for the EPUB3 format. Print equivalent page numbering, available as accessibility metadata, is useful because regardless of the page number indicated in the etext the print page number remains the same. This allows the user to determine the exact location in the printed version of the book if the academic publisher or academic aggregator provides an electronic counterpart.

Additional metadata useful to accessibility was also discovered when undertaking the searches of the PDF and EPUB3 standards. For example, copyright status within the PDF and PDF file size can also be determined. In addition to this there is a custom properties tag within the PDF format that can be used by the academic publisher to provide contact details. This would mimic the accessibility metadata tag specifically designed for this purpose in the EPUB3 format. This relies, however, on the publisher not only being aware of this feature but also using it when creating an accessible epublication.

Although API libraries, at the time of writing, are available for the three mainstream mobile devices, namely Android, iOS and Windows, it was found that there was limited API accessibility support. This was also the case for the cross platform mobile browsers Chrome, Firefox and Opera. The Safari and Explorer mobile browsers were not supported by Android at the time of writing. This information is useful because it provides the core API accessibility support across all three mainstream mobile operating systems and cross platform mobile browsers. These features would provide a starting point for the ereader component of the academic or student web application. The web application, however, may have limited access to the device API's. It was also necessary to include these features in the instrument. 10 features were predominant.

Physical and sensory controls against user tasks	WCAG 2.0 (A,AA,AAA)	Feature/Selector (Device & Mobile Browser)	Input/Output	DISCOVERY						ECONTENT FORMAT						DOWNLOAD		UA EREADER										Scoring						
				Institute Authentication - Institute Library	Institute Portal Steps - Institute Library	Search 1 & Search 1 Result(s) - eg. Web of Science search	Search 2 & Search 2 Result(s) - Educational Publisher	Preview Paper Abstract - Educational Publisher	View Accessibility Metadata Prior to Download - Educational Publisher	Fast Web View	PDF				ePub3		Search 2 Result - Publishers website.	Dialogue		Authentication & Synchronisation	View Format Metadata in UA	Help	Import eText, Library (eText Shelf) & Library Search	Manage Local Downloads & Third Party Storage access within the UA	Plugin Usage	Document View & Screen Orientation	Manage Bookmarks & Links Menu	Progression & Lookup	Search eText	Step (25 Overall User Tasks)	Total Accessibility (%)			
											Accessibility permission flag is set	Accessibility report attached to document	Document is tagged PDF	Custom Properties	IDPF: Accessibility Summary (eg . contains MathML etc.)	Onix Code 10: No reading system accessibility options disabled		Onix Code 99: Publisher contact for further accessibility information																
Print Impaired User																																		
1	Visual Controls	SC 1.4.3. (AA); SC 1.4.6. (AAA); SC 1.4.8. (AAA)	Output																															
2		SC 1.4.8. (AAA); SC 3.2.3 (AA); SC 3.2.4. (AA)	Output																															
3		SC 1.4.4. (AA); SC 1.4.8. (AAA)	Output																															
4	Touch Controls	SC 1.3.3. (A); SC 2.1.1. (A); SC 3.2.1. (A)	Input																															
5	Audible Controls	SC 1.3.1. (A); SC 3.1.5. (AAA)	Output																															
6		SC 1.3.1. (A)	Output																															
7	Voice Controls	SC 4.1.2. (A)	Input																															

Table 35: The updated framework components incorporated into the instrument and metric.

Three core device and cross platform mobile browser settings related to themes and styles, namely:

1. Text colour;
2. Background colour;
3. Font family/typeface.

Whereas four core device and cross platform mobile browser settings related to adjusting white space around onscreen text:

4. Margin spacing;
5. Line spacing;
6. Character/letter spacing; and
7. Left justification (ragged right).

Two device and cross platform mobile browser settings were related to resizing text and on screen content:

8. Text/font size;
9. Zoom/magnification.

Rello and Barbosa state that font type, font size, text and background colour, and character spacing are essential requirements for ereaders used by those with dyslexia (Rello and Barbosa, 2013). The tenth setting was for device gestures, such as settings relating to altering focus for navigation by a screen reader user. This also included switch controls for those with motor impairments.

Two other features that specifically accommodate dyslexia are Read Along and synonyms on demand as suggested by Rello and Baeza-Yates (2014). Neither of these features had API accessibility support for the three device platforms or the mobile browsers. These features were only supported in ereader applications, such as Ideal Group Reader for synonyms on demand and VoiceDream for Read Along. Another feature that had minimal API accessibility support was that of themes, whether this was for pre-set text and background colour options or fully customisable colours.

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Less predominant, but nonetheless still available, the features for full screen and reflowable text alongside controlling screen orientation and screen reader support were evident for both the device and cross platform mobile browsers. Interestingly the W3C have discontinued working on the full screen API (W3C, 2014) even though there is still support for this feature in device and mobile browser API libraries. Having said this though Whatwg are currently working on a full screen API (van Kesteren, 2019).

Another feature worth mentioning is that of voice recognition. Voice recognition is more about recognising a voice for actions on a device whereas speech recognition is about recognising what is said so it can be converted into text. Each of the mainstream devices support the voice recognition API whereas only the Chrome mobile web browser supports this feature. It is worth mentioning that the quality of voice recognition is dependent on large speech datasets typically only available through large corporations such as Google. In addition to this, although all three mainstream mobile devices support TTS APIs there was no API accessibility support for the mobile browsers regarding this feature.

Highlighting existing accessibility APIs, those currently being worked on and those not yet available in this context is important. It is also essential to incorporate this aspect into the instrument in that it provides a comprehensive matrix for both existing and future accessibility API's within the HEI library mobile web ecosystem.

The purpose of Expert Review Two was an evaluation of the instrument and not a validation of the metric. It also set out to first complete the framework and then find out if a prototype would work and could be used. The Subjective Knowledge (SK) Likert scale ratings for expertise used in the review indicated that perhaps three out of the eight participants were unsure as to what the distinction between mobile accessibility and mobile web accessibility meant. Whereas the scoring was higher for the term Web accessibility. Also, since the intervals between the scales were not stipulated, these could only be used for general guidance.

Brajnik et al suggest that as a requirement experts answer questions relating to actual expertise and knowledge as well as their own views (Brajnik et al., 2011). For instance, the number of years worked as a consultant/specialist was at the high end of the scale ranging from six to 16 or more years. Although the majority of the expert participants had

tested more than 10 websites in the last six months, only two had tested more than 10 mobile applications for accessibility in the last six months. Another revealing aspect of the review was that no expert participants had tested more than three mobile browsers for accessibility in the last six months. This seems to suggest an area that needs to be addressed within evaluating mobile web accessibility, especially for mobile web applications as emphasised by James et al. (2017).

Since four individual experts agreed and one strongly agreed that the prototype and the automatic BW success criteria would work on an HEI library web portal this was seen as encouraging. More specifically two of the expert reviewers, with over 16 year's experience, agreed and one participant with 11 – 15 years' experience agreed. The participant who strongly agreed had 6 – 10 years' experience. This suggests that the automatic BW success criteria generated by the instrument and the prototype are heading in the right direction. However, since only one expert participant strongly agreed this would seem to indicate that further analysis is required.

In terms of the prototype and the automatic BW success criteria working on the publisher's website one expert participant agreed and two expert participants strongly agreed out of a total of 8 participants. The participant who agreed had over 16 years' experience whereas the remaining two experts who strongly agreed had 6 – 10 and 11 – 15 years' experience respectively. Although these are positive indications the sample size, based on the number of questions answered, falls below the minimum requirement of eight. Future studies repeating this survey would need to ensure not only a greater number of participants but that also all the questions required are answered fully by the participants.

Six out of the eight expert participants stated that there was no need to remove items from the evaluation success criteria and user tasks. One expert participant stated that: 'if anything you may need to add alternatives where the portals are found to be different to your example.' This is a valuable insight in that not all HEI library web portals will be identical and this needs to be addressed in any future analysis.

The individual expert participants were also asked their opinion about what accessibility requirements are necessary for the mobile web accessibility of HE electronic texts for

print impairments. Two main accessibility requirements were emphasised by two participants. These were that the HEI library web portal and the etexts provided through the portal must be accessible to the academic or student user. The remaining expert participants reinforced this statement by referring, for example, to the accessibility features that would be essential on the web portal and the publisher's websites. In doing so seven expert participants corroborated the accessibility requirements based on their statements.

In addition to this one expert also stated that 'there needs to be a bridging of the gap between the AT offered on mobile web applications and the digital accessibility offered by publishers with an increase in metadata as well as an understanding about what makes an etext accessible.' This corroborates the tenet developed throughout this thesis that accessibility evaluation must not be undertaken in isolation, particularly, as the expert participant put it, in terms of bridging the gap.

Another expert participant, however, provided an alternative perspective to that of the academic or student user. In this instance that the HEI librarian questioning whether the language of the accessibility evaluation was too technical. The participant also queried whether this accessibility evaluation process would reduce the amount of alt-format requests the library would be required to process.

In both cases the language of the accessibility evaluation and whether the alt-format requests would reduce has been dealt with in the design of the four web applications. The stakeholder interaction afforded by these web applications solves both problems.

One of the experts who is an academic publisher, analysed each of the four tasks (tasks 4, 5, 6 and 7) and used the Likert scale rating in order to do so. Task 6, in reference to the exposure of accessibility metadata, made available on the academic publisher's website was scored as one. Indicating that there was no provision for this feature on the publisher's website. Ad hoc searches across academic publishing websites seemed to suggest that no accessibility metadata is exposed to the user regardless of the format. If this is addressed, as Garrish suggests in reference to the EPUB3 format, users would be able to determine if the format provision by the academic publishers will meet their accessibility requirements prior to download (Garrish, 2012).

Since the majority of the expert participants agreed that the automatic BW success criteria would work on an HEI library web portal this research dovetails with research that explores the potential of adaptive mobile technology. Sloan et al refer to older adults who may experience co-occurring age-related disabilities, that include cognitive impairments, and how personalisation can be advantageous for this user group (Sloan et al., 2010). In the future this may also warrant further investigation particularly for government web portals.

The personalisation of accessibility features on a portal, based on the accessibility requirements of those with print impairments, would enable users to search for, find, download, navigate and read etexts within a mobile web environment. The level of personalisation possible for the user would be set by the number of API calls available across this ecosystem. One of the potential issues with being able to evaluate the mobile web accessibility in this context is that of obtaining permissions within web applications.

One potential workaround to this is not recording device accessibility settings usage, but to only determine if the device has a particular accessibility feature available API calls. Admittedly this would not provide the cause of any potential accessibility barrier but it would determine what features are available if an accessibility barrier was encountered. The other option is that the user is asked to provide permission when downloading the web application with a statement stating that the data will enable improvements to be made to the application.

7.2.1 Limitations

The qualitative statements made by the individual experts addressed seven key limitations relating to the Expert Review Two evaluation, that were sent out as anonymous surveys rather than face to face, namely:

1. Clarification in the survey of whether it was the prototype or walkthrough being reviewed;
2. The technical language and terminology of the prototype and walkthrough that should be common to all stakeholders;

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3. Only one HEI library web portal was assessed, and that alternatives for other portals needs to be integrated;
4. The granularity of the instrument may impact stakeholder adoption;
5. Providing a scoring for a specific component of the framework, such as a web page or website used during discovery;
6. Issues with the user interface of the prototype; and finally
7. One issue with the automatic BW success criteria.

These are important because they provide a bearing on why two of the expert reviewers gave neutral scores. One expert gave a neutral score because they felt it was unclear as to whether it was the prototype or the walkthrough being reviewed. The walkthrough included the HEI library web portal and the hand over to the academic publisher's website; whereas the high fidelity prototype simulated an application that allowed ereading of an academic paper. The following wording was specified on the questionnaire that was sent out anonymously using iSurvey (see Appendix H).

'This section identifies key issues for mobile web accessibility and provides you with a list of checks that will help you evaluate your Institute library portal or publishers website based on the use of a prototype tool.

Walkthrough and Prototype: The walkthrough and prototype [...] has been designed to give, you the expert, an overview of a process undertaken by the academic or student for discovery and download of HE etexts.'

The two critical questions that required an answer by the participants were:

1. On a scale of 1 to 5 do you agree that the tasks 1 - 3 work on your institute's library portal?
2. On a scale of 1 to 5 do you agree that the tasks 4 - 7 work on your academic publisher's website?

The following wording was also provided on the questionnaire:

'Important: If you are a publisher please answer question nine. If you are a librarian please answer question seven. It is also important to answer the remaining questions'.

When the expert participant reached either question seven or nine they were again reminded with the following wording:

‘Question 7. If you are a librarian it is important to answer this question’, and again for ‘[q]uestion 9. If you are a publisher it is important to answer this question.’

If, however, the expert was not a librarian or an academic publisher the following wording was also included:

‘Please note: if you are from another profession please use the prototype as an example and answer only one of the questions nine or seven, with your publishers or librarians 'hat' on.’

Although this information was provided one expert participant did not answer either question seven or nine. Only four participants answered question two relating to the academic publishers website. This adversely impacted the results.

Another expert gave a neutral score because they suggested that the walkthrough and prototype should be undertaken in the desktop HE environment rather than within the mobile context. This was considered to be a significant issue for the automatic BW success criteria and had to be addressed. One of the main reasons why the desktop environment was not considered within the remit of this thesis was that there is a significant blurring between the desktop, laptop and mobile domains as specified by (W3C, 2015b). Published research findings have shown that computer desktop notebooks are mainly used for undertaking assignments; whereas tablets are used predominantly for ereading, and the more these are used the more mobiles are adopted within HE (Cheung, 2015).

The type of technical language and terminology of the prototype and walkthrough was raised by the individual experts as not being appropriate to stakeholders. This has been dealt with in chapter eight, by producing a wireframe for an application that emphasises stakeholder interaction between HEI librarians, academic publishers, academic publishers and print impaired academic or student users. The language and terminology of the instrument and metric has also been made appropriate for design and development teams involved in the development life cycle of the mobile web accessibility evaluation

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tool aimed at the HE etext ecosystem for those with print impairments. It also formed the basis for writing the mobile web accessibility specification that is referred to in chapter eight.

The individual experts commented on the fact that only one HEI library web portal was assessed in the walkthrough. It was necessary to focus on one web portal first in order to determine if the automatic BW success criteria would work in the required HE environment. Although in the survey it asked the experts to compare the example web portal with their own web portal this was difficult to do and, as pointed out by the individual experts, there may be insurmountable differences that may affect the results. This would be an important factor to take into account for the next iteration of the automatic BW success criteria and to evaluate the outcome on a variety of different HEI web portals in the future.

In order to test the automatic BW success criteria a manual check was undertaken on the Bluefire Reader application; but this could only test the download and UA ereader component, and one single aspect of the metadata component. This did not allow the entire instrument to be tested but it did suggest that each individual component could be given a total sub score. This showed that it was possible to gain sub scores and that these tests should not be undertaken in isolation.

It would also provide a scoring on the accessibility support made available within this ecosystem. One expert reviewer identified the same potential problem but just referred to evaluating a web page. This sub scoring across components would need to be undertaken with the ultimate goal in mind, to prevent isolated evaluations within this ecosystem.

The granularity of the instrument, namely the difference between too many and too few checks, was also referred to by the individual experts as this could affect stakeholder adoption as suggested by Vigo and Brajnik (2011). The aim of the instrument was to enable a specification for an automatic mobile web accessibility evaluation tool to be written. This could then be used by developers, HEI librarians and academic publishers. Since it is automatic the number of evaluation criteria is not an issue for adoption by

these stakeholders but would require verbosity control on any report it produces as suggested by Ulltveit-Moe et al. (2008).

The individual experts referred to what appeared to be potential issues with the UI of the prototype, such as: no reference to DRM access; the provision of help pages; no mention of switch control access; and the decluttering of the screen. These were all issues that were identified prior to undertaking the expert review and were omitted in the abridged version of the review to save time. The comments made by the individual experts were valuable because they corroborated the findings already included in the instrument and metric.

One aspect not included in the instrument and metric, but that has been included in the specification and wireframe in chapter eight, was the ability to provide an accessibility rating for an epublication, regardless of its format. This was raised by one of the expert participants, who also suggested including built in accessibility tools in the prototype. This was addressed in part by providing the means to customise accessibility features in the prototype, and in the wireframe, detailed in chapter eight, and the ability for the user to hand over to an external system such as Sensus-Access that provides alt-formats through conversion (Christensen and Stevns, 2017).

One expert participant referred to ensuring that 'colour changes don't interfere with icon distinctiveness - eg in demo the Yellow text on Black makes the two 'Aa' icons look identical even though they do different things'. This was noted and will form part of the future work when developing the full academic or student version of the web application that enables ereading.

7.3 Chapter summary

Expert Review Two used a high fidelity prototype of an HEI mobile web application ereader in tandem with a walkthrough of the University of Southampton library web portal for a mobile device. The prototype and walkthrough used for the review were based in part on a written specification and the design of a wireframe informed by the automatic BW success criteria generated by the instrument. The main outcome of Expert Review Two was that the prototype and walkthrough worked for an HEI library mobile

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web portal. This was based on the evaluation of a representative example of the automatic BW success criteria. In particular, the exposure of etext format accessibility metadata on the academic publisher's website within the prototype and walkthrough. This was taken forward by producing a full specification and a wireframe for a mobile web accessibility evaluation tool that enables stakeholder interaction.

The review also revealed that no experts had tested more than three mobile web browsers for accessibility and that four out of seven experts had not used reflow when reading a PDF. These findings were taken forward by emphasising recommendations for future mobile web accessibility evaluation and the marketing of accessibility features within the PDF by Adobe. This emphasised the need for establishing if PDF and EPUB3 format accessibility metadata could be programmatically determined. It also highlighted the need to determine what mobile browser API accessibility support was available.

Although the individual expert reviewers did highlight limitations with the prototype and walkthrough the majority of these were already addressed in the full specification and wireframe. For example, stakeholder appropriate language was raised as an issue in the review but this was addressed in the wireframe. The reason the full specification and wireframe were not included in the review was because of the time it would take the reviewers to undertake an evaluation. The limitations that were not addressed in the full specification and wireframe were issues with the user interface. These were taken forward as items for future work.

The automatic mobile web accessibility evaluation tool was incorporated into four separate mobile web applications and a web service that could be used by academics/students, HEI librarians, academic publishers and academic aggregators.

The results for whether the PDF and EPUB3 format accessibility metadata could be programmatically determined by AT provided one of the main changes. It was realised that, for example, the econtent component of the five new framework components could be subsumed into the etext format component and was renamed to econtent format. For example, the H1 – H6 metadata tags available within the PDF format can be programmatically determined and are critical to evaluating a PDF for navigation within

the semantic structure of a document. This meant that the framework components could be reduced to four, namely:

1. Discovery;
2. Econtent format (including accessibility metadata);
3. Download; and
4. UA Ereader.

Establishing that PDF and EPUB3 accessibility metadata could be programmatically determined changed the instrument. This was from manually checking automatic evaluation criteria, theoretically available, by experts to evidence for actual accessibility metadata that could be automatically evaluated. The instrument also provides automatic BW success criteria for features that may not exist in current mobile ereader applications.

Expert Review Two enabled the framework to be completed by reducing the number of components to four and in doing so it is likely to positively impact stakeholder adoption as suggested by Vigo and Brajnik (2011). It will also reduce the verbosity of the reports the automatic evaluation tool will need to produce, a requirement specified by Ulltveit-Moe et al. (2008). Expert Review Two determined if a prototype and walkthrough could be used on an HEI library web portal using a mobile device. Creating a prototype HEI ereader web application alongside a walkthrough of an HEI web portal helped demonstrated how to use accessibility metadata, the framework and instrument. In addition to this the first iteration of the mobile web accessibility evaluation tool provided a proof of concept that extracted accessibility metadata from a PDF on demand through a web service.

In doing so this exposes the limited availability of current accessibility metadata that can be programmatically determined for an automatic mobile web accessibility evaluation tool. This is specific to mainstream mobile device platforms, mobile browsers, ereader applications and within the PDFs and EPUB3 formats. It goes significantly beyond providing accessibility metadata for searches undertaken on Resource Discovery Tools (RDTs) in HEI libraries as suggested by Beyene and Godwin (2018). Although the availability of current accessibility metadata in this ecosystem maybe limited this research provides a rationale for why it is necessary. It identifies the accessibility features across

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mainstream mobile devices and UAs that are incorporated into the specification and wireframe. This also calls for further development of accessibility metadata especially for reading HEI etexts on mobile devices. This research lends itself to the potential of adaptive technologies providing personalisation of features for mobile devices and UAs within an HEI library mobile web ecosystem.

The other reason this helps the development of the thesis work is that it integrates device characteristics into the framework and is inline with research undertaken by Vigo et al. (2008). In particular it enables mobile web accessibility evaluation to be achieved irrespective of the UA characteristics, software and hardware as referred to by Vigo et al. (2008). It does not, however, rely on third party repositories for device descriptions and exceeds the research undertaken by Vigo et al. This research helps to address the now 10 year old MWBP 1.0, meeting the request made by Kaur and Dani (2017).

Chapter 8 Specification and wireframe

This chapter contributes to how both RQ1 and RQ2 were answered and provides a specification for an automatic accessibility evaluation tool, in conjunction with a wireframe for a web service and four web applications. The purpose for the investigation was not a validation but a demonstration of how to use the accessibility metadata, framework and instrument by specific stakeholders. The automatic accessibility evaluation tool determines how to evaluate the mobile web accessibility of HE texts for those with print impairments with two main outcomes.

Firstly, providing a proof of concept tool that extracts accessibility metadata from a PDF. This tool is the first iteration of the automatic accessibility evaluation tool. It can be used by academics/students, HEI librarians, academic publishers and academic aggregators when incorporated into a web service and four web applications. These web applications, supported by the web service, enable stakeholder interaction. In addition to this, the web service combined with the web applications will provide, in real time, the demand for accessible publications and so provide tangible results to the academic publishing sector.

Secondly, it allows for the implementation of a common language between stakeholders, a requirement identified during Expert Review Two. For example, academic or student stakeholders may be aware that they require yellow text on a black background and know that by using a high contrast mode setting this will change the colours in an accessible document. However, they may not realise what is required to make that document accessible. For example, if a PDF has been provided, that prevents this configuration for high contrast such as one provided as a scanned image, the web application enables the print impaired academic or student user to flag the issue.

They can then have an alternative provided by the academic publisher/aggregator or the HEI library without requiring a technical understanding of accessibility and the terminology used. In addition to this, the terminology used in the web applications would also accommodate a common language between stakeholders. For example, instead of using the term visual controls, as specified in the instrument, the words 'visual settings' have been introduced as seen in most smartphones.

Chapter 8: Specification and wireframe

Once established, a complete wireframe of the entire service was produced providing a breakdown of how the stakeholder interaction occurs with a use case diagram (see Appendix I). In addition to this, provision has been made for both a lite (free) version and an HEI library version of the academic or student web application. Another requirement identified during Expert Review Two was the need for academic or student users to be able to determine what DRM restrictions were issued on a particular format, such as a restricted PDF within the application. The academic or student web application accommodates this feature. The HEI library, academic publisher's and academic aggregator's web applications also allows control over the verbosity of the reports produced by the web service as it does when using the accessibility evaluation tool.

The completion of the instrument led to a specification being written and a wireframe being designed for the four web applications and web service. The first iteration of the accessibility evaluation tool took the form of a proof of concept tool that extracts accessibility metadata from a PDF.

8.1 Specification

The automatic BW success criteria generated by the instrument enabled a specification to be written for the accessibility evaluation tool. The specification briefly explains the problem that the publishing sector is missing out on 25% of its market share, even though the academic publisher's state that they are not receiving 700 requests per day. The specification then explains the solution, as referred to in this work, and the benefits. The benefits, for example, for the academic publisher include:

- Data relating to the demand for inaccessible etexts. In doing so this data will also help establish the priority of demand. So for example, if 1000 inaccessible flags are requested for a particular document over another single inaccessible flag for a document, the priority is clear.
- The means to quickly fix accessibility issues.
- The ability to promote their own titles similar to those downloaded by the user.
- Valuable research data for the marketing departments in publishing houses.
- Access to an academic publisher lookup ranking in one place.

- Accessible devices tested by experts through a feed from Web2Acces¹ that can be resold by the industrial partner to be promoted through the academic publishers marketing channels.
- An ereader that the academic publisher can be confident the accessible format they provide will not be made inaccessible by the ereader or academic aggregator.
- Customisation, and potential personalisation, of electronic etext content for the academic or student user in HE who is print impaired.

The specification then refers to the stakeholder interaction between the:

1. Academic or student;
2. HEI Librarian;
3. Academic publisher; and the
4. Academic aggregator.

In doing so a use case diagram is provided, see Appendix I. The entire specification was written to provide an overview for the developer to gain an understanding of how each component would function and the requirements for development. The requirements for development, see Appendix I.1.5, were separated into three priorities, namely:

1. Release 1: Essential;
2. Release 2: Desirable; and
3. Release 3: Future (includes later releases).

This was done so that a developer could code the first iteration of the accessibility evaluation tool that would then be incorporated into a web service and four web applications. The highest priority within the essential requirements was to provide a proof of concept tool for extracting PDF accessibility metadata through the use of a web service.

¹ <https://web2access.org.uk/>

8.1.1 Proof of concept tool

The specification enabled a proof of concept tool to be developed. Two specific aspects of accessibility metadata were extracted from a test PDF. Figure 26 indicates the tags for 'taggedPDF' and 'language'. The other metadata extracted is useful in terms of accessibility. This is because other metadata may support the accessibility of the document. For example, page count is metadata that can be extracted from the PDF and enables a reader to be aware of pagination extent. If the document is large, such as this thesis, the user would be aware that they need to perhaps consider using bookmarks in the PDF and or links, if they are provided, in the contents page of the PDF document.

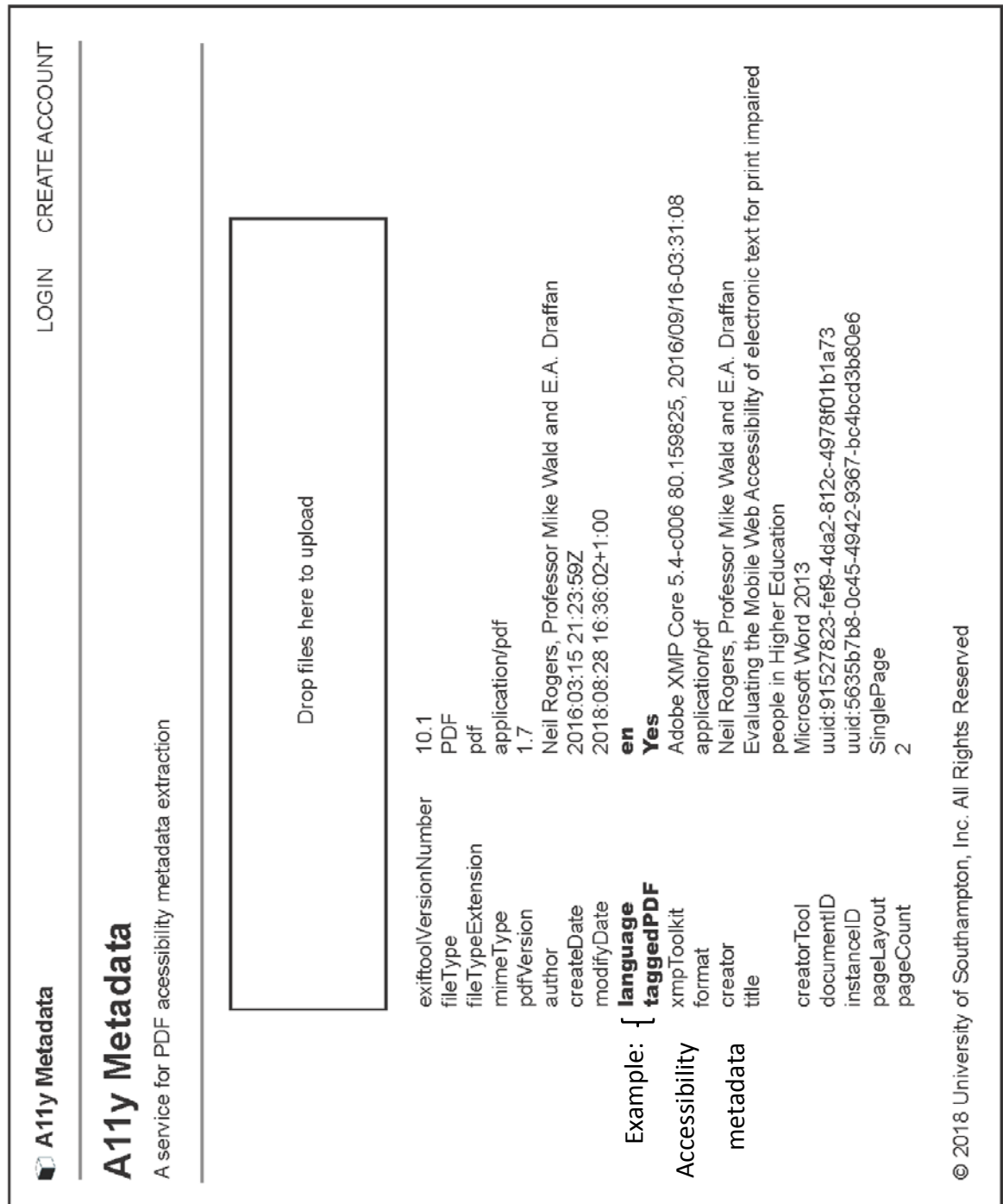


Figure 26: Proof of concept PDF accessibility metadata extraction tool.

8.2 Wireframe

The specification included a walkthrough skeleton, otherwise known as a wireframe, and focused on the four stakeholders, see Appendix I.1.5 for the detailed breakdown. User stories were provided for each stakeholder in the form of a wireframe, these wireframes provide the essential structure of what each stakeholder was required to do when using the respective web applications. For example, the academic or student user interacts with

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a web application that enables ereading to take place, this application then automatically updates the HEI library, academic publisher's and academic aggregator's web application simultaneously depending on what the academic or student requires. Another important aspect of the web application is that it has both online and offline capabilities.

Two versions of the academic or student web application were provided, namely the:

1. Lite or free version; and the
2. Institute branded version.

The lite or free version provides access to Open Access materials only for guest users; whereas the institute branded version provides access to both open and restricted access of copyrighted materials through an institute account. Enabling stakeholder interaction reinforced the need for a common language, as identified in Expert Review Two, between the academic or student user, HEI librarian and the academic publisher and academic aggregator. For example, 'viewing the screen' was used instead of referring to visual controls. It was for this reason that quick start guides were also included in the wireframes.

The lite or free version of the web application includes the following general settings. The wireframe provides a comprehensive breakdown of each setting. One aspect of the lite or free version to consider would be the inclusion of the *inaccessible flag feature for inaccessible Open Access etexts.

- **Tutorial & Help Documentation**
 - Quick Start
 - Full Walkthrough
 - Smart Notifications
 - Help Documentation
 - Turn On/Off
- **Accessible etext Devices (Guest)**
 - Search for Device
 - Invite a friend
 - Share on Facebook or Twitter
- **Open Access etext Search (Guest)**
 - Invite a friend
 - Share on Facebook or Twitter
- **Institute Login (Registration)**

- **Stakeholder Interaction**
 - *Inaccessible Flag
 - Simple
- **Download/Transfer**
 - Local
 - Cloud Storage
- **Document Management**
 - Folder Options
- **Reference Manager (Release2)**
 - Audio Annotations
 - Share Annotations (Collaborate)
- **Manage/Library of Voices**
 - Free
 - Purchase
- **Customisation**
 - *Navigation (touch)*
 - Menu Text Size
 - Finding/Searching
 - Speech Recognition
 - *Viewing the Screen*
 - Zoom
 - Reflow
 - Colour Changes:
 - Background Colour
 - Font Colour
 - Saturation
 - Readability & Legibility
 - Style of Font
 - Font Size
 - Font Colour
 - Background Colour
 - Saturation
 - Text Alignment
 - Line Spacing
 - Margin Spacing
 - Overlay
 - Overlay Options
 - Full Screen Reading
 - Readability On/Off
 - *Audio*
 - Text to Speech
 - Rate of Speech

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- Pronunciation
- Voice Library
 - Purchase Voices
- User Behaviour Analytics
 - On/Off
- Cloud Storage
- Sign Out & Close

- **Permissions**
- User Behaviour Analytics
- Cloud Storage
 - Google Drive
 - Dropbox
- Temporary User Preferences

- **Notifications**
 - On/Off
- **Online/Offline Functionality**

The institute academic or student version of the web application includes the following general settings. The HEI library sets up the branded institute application that is then made available to the academic or student for institute ereading purposes.

- **Tutorial & Help Documentation**
 - Quick Start
 - Full Walkthrough
 - Smart Notifications
 - Help Documentation
 - Turn On/Off
- **Branding App**
 - Templates
 - Import Corporate Stationery
- **Accessible etext Devices (Institute)**
 - Search for Device
 - Invite an institute friend
 - Share on Facebook or Twitter
- **Open Access etext Search (Institute)**
 - Update Academic Search Engine list from HEI Library (Set to Auto)
- **Institute etext Search**
 - Update Academic Search Engine list from HEI Library (Set to Auto)
- **Stakeholder Interaction**

- Inaccessible Flag
 - Simple
 - Complex
 - Send Options
 - Passed Check (Inaccessible)
- Audit Report
- Invite institute friend
- Barrier Recording (Release 2)
- **Download/Transfer**
 - Local
 - Transfer
- **Document Management**
 - Folder Options
- **Reference Manager (Release 2) *eg.***
 - Audio Annotations
 - Share Annotations (Collaborate)
- **Manage/Library of Voices**
 - Free
 - Purchase
- **Customisation**
 - Navigation (touch)
 - Menu Text Size
 - Finding/Searching
 - Speech Recognition
 - Viewing the Screen
 - Zoom
 - Reflow
 - Colour Changes:
 - Background Colour
 - Font Colour
 - Saturation
 - Readability & Legibility
 - Style of Font
 - Font Size
 - Font Colour
 - Text Alignment
 - Line Spacing
 - Margin Spacing
 - Overlay
 - Overlay Options
 - Full Screen Reading
 - On/Off
 - Readability On/Off

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- Audio
 - Text to Speech
 - Rate of Speech
 - Pronunciation
 - Voice Library
 - Purchase Voices
- **User Behaviour Analytics**
 - On/Off
- Cloud Storage
-
- **Authentication**
- Registration
- Login
- Change User
-
- **Permissions**
- User Behaviour Analytics
- Cloud Storage
 - Datanywhere
 - Google Drive
 - Dropbox
- Temporary User Preferences
- **Notifications**
 - On/Off
- **Online/Offline Functionality**

It was necessary to include a means for academic or student users to be able to flag an inaccessible etext even if it passes an accessibility evaluation using the relevant web application. In doing so this prevents minimal intervention by the HEI library and the academic publisher and academic aggregator, and ensures that remedial action is taken to address the accessibility barrier.

The academic publisher and academic aggregator version of the web application includes the following general settings.

- **Tutorial & Help Documentation**
 - Quick Start
 - Full Walkthrough
 - Smart Notifications
 - Help Documentation

- Turn On/Off
- **Branding App**
 - Templates
 - Import Corporate Stationery
- **Stakeholder Interaction**
 - Academic or student Authentication
 - Sensus Access Authentication
 - RNIB Bookshare Authentication
 - Bespoke Services Authentication
 - *Demand*
 - Inaccessible Flag Requests
 - Status Reports
 - View
 - Update
 - Analytics
 - Visualise Data
 - Interrogate
 - *Validation*
 - PAVE (PDF)
 - EPUB Checker
 - Pass Reports
 - Fail Reports
 - *Fixing*
 - PAVE PDF
 - Quickfixes
 - Document Settings
 - Document Content
 - *Testing* (Release 2)
 - eReader Testing
 - Disability Simulation
 - DRM Extension
 - Requests
 - Download Timeout
 - Upload/Send
 - Upload
 - Job Requirement (to Sensus Access, RNIB Bookshare, Bespoke Services)
 - Send
 - Accessible Document (to Academic or Student)
 - Publisher Lookup Ranking
- **eReaders Tested for Accessibility**
 - Web2Access Feed

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- **Authentication**
- Registration
- Login
- Change User

- **Permissions**
- User Behaviour Analytics
 - Yes/No
- Cloud Storage
 - Datanywhere
 - Google Drive
 - Dropbox
- Temporary User Preferences

- **Notifications**
 - On/Off

- **Online/Offline Functionality**
- **STEM**

The HEI librarian's version of the web application includes the following general settings.

- **Tutorial & Help Documentation**
 - Quick Start
 - Full Walkthrough
 - Smart Notifications
 - Help Documentation
 - Turn On/Off
- **Branding Library App**
 - Templates
 - Import Corporate Stationery
- **Sensus Access Administration**
 - Incoming
 - Outgoing
- **Stakeholder Interaction**
 - Branding Institute App
 - Templates
 - Import Corporate Stationery
 - Deploy
 - Authenticate Academic or Student
 - Authenticate for Sensus Access

- Authenticate for RNIB Bookshare
 - Authenticate for Bespoke Service
 - Inaccessible Flags
 - Academic Orders
 - DRM Extension
 - Publisher Requests
 - Publisher Lookup Ranking
- **Legacy**
 - Alert
 - Import
 - Send
 - Legacy Watched Folders
 - Setup
 - Send
 - Academic
 - Student
- **eReaders Tested for Accessibility**
 - Web2Access Feed
- **Authentication**
- Registration
- Login
- Change User
- **Permissions**
- User Behaviour Analytics
 - Yes/No
- Cloud Storage
 - Datanywhere
 - Google Drive
 - Dropbox
- Temporary User Preferences
- **Notifications**
 - On/Off
- **Online/Offline Functionality**

8.3 General Discussion

The two main findings from writing a specification and producing a wireframe, based on the automatic BW success criteria generated by the instrument, were the potential for stakeholder interaction and determining the demand for accessible publications.

When writing the specification and designing the wireframe it was found that a patent existed as specified by Vitthal and Kumar (2017) that described a different version of this service. It makes provision for visual impairments and not for a range of print impairments, so does not include dyslexia and motor impairments. The patent refers to a multi-channel ecosystem, but does not specifically refer to the provision of an automatic mobile web accessibility evaluation tool, nor does it refer to an application that offers stakeholder interaction and real-time automatic evaluation of accessible documents on demand.

Four web applications were designed and developed using the instrument automatic BW success criteria. The tool would undertake automatic evaluations using the instrument automatic BW success criteria and metric. In order to begin development, a specification was written based on the instrument for the automatic mobile web accessibility evaluation tool. This led to a proof of concept tool being developed, that demonstrated that through a web service accessibility metadata can be extracted from a PDF on demand. The specification written provided specific details about the accessibility metadata and what tags were required for both the PDF and EPUB3 using the PDF/UA (ISO, 2014) and IDPF (2017) accessibility metadata specifications.

The walkthrough and the high fidelity prototype used in Expert Review Two provided the basis for the wireframe and the user stories for both an institute version and a free version of the proposed application. The free version of the web application would provide open access search, such as that made available through Project Gutenberg; whereas the institute version would provide access to restricted and copyright material through a single sign on, such as Shibboleth authentication credentials. In addition to this, three other web applications could be developed using the instrument and checklist and would be for the HEI librarian, the academic publisher and the academic aggregator. The

entire suite of four web applications would be supported by a web service, as suggested by Arrue et al, that uses a separate library for different versions of the instrument and mobile web accessibility guidelines (Arrue et al., 2007).

The web service does require hosting and can be setup to automatically heuristically evaluate PDFs in bulk for their accessibility metadata. For example, reading order cannot be automatically determined for a PDF. If, however, a publisher manually checks the PDF for reading order and then checks a radio button in the accessibility report this metadata can be exposed in human readable form.

The complete accessibility evaluation tool provided the means for an application that allows stakeholder interaction. It also enables the demand for accessible publications to be determined. The academic or student web application will not be an ereader but will allow ereading to take place. By default this version of the web application will offer reflow for all PDFs but will also make the fixed layout option available, highlighting this feature on first login. When producing the high fidelity prototype the researcher, through hands on assessment (Whitehouse, 2011), established that 15 characters, including spaces, would fit the width of an Android Nexus 5 at 18pt the point size stipulated by Rello (2014). 15 characters would allow for up to three words per line. However, word length would impact the number of words per line.

Although the web applications would be responsive the layout of the academic or student web application interface would need to maximise reading space to allow for a text size of 18pt (24px). This is one of the main reasons why a full screen mode was integrated, as this also helps to declutter the screen, meeting in part the essential accessibility requirement of simplification (Rello et al., 2013) for those with print impairments. Not only would decluttering help to achieve this, but the simplification of the features made available to the user through the interface would also need to be addressed. This would also ensure that cognitive impairments would be accommodated as recommended by Newell (2011). Although not an ereader application, an example of a simplified user interface in the mobile web context would be the Google mail mobile application. Through hands on testing the researcher was able to determine that the google mail application presented the user with only the essential features required for a specific task

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on a specific page of the web application. For example, when opening the application three features are made available:

1. The burger menu;
2. Search; and a circular button with a pencil icon to
3. Write emails at the bottom right of the screen.

Although the burger menu provides additional options to select, the main window for the application is simple to use. The VoiceDread reader UI, an application recognised for addressing accessibility particularly for dyslexia, has 11 options available on the main user interface.

Anonymous user behaviour analytics have also been included in the four separate web applications and are triggered when permissions are requested at run time. The stakeholders would need to be informed that allowing these permissions to gather this data will help further research and improve the service for the future. This would provide the means for on device testing and assessing accessibility in use as suggested by Vigo and Harper (2013). In doing so it would enable evaluation for a web application running on a mobile device that allows ereading of the PDF and EPUB3 formats. The data generated from this would be stored by the web service, and also has the potential to feed into the research undertaken by the crowd sourced ebook auditing being undertaken by JISC and other relevant organisations as specified by McNaught (2018).

The academic or student web application provides meta-searches across the main academic search engines and also includes google scholar. This feature would be able to integrate search engine API's, such as that used by Semantic Scholar. The HEI library would be able to determine which search engines they decide as being most beneficial to the core reading requirements of their academic or student population. Providing this feature in one place, through a UI that has been tested using the mobile web accessibility evaluation tool will help not only help print impaired academic or students but potentially all users. In addition to this, the academic or student web application has offline capabilities, operating using a cache and updating when it is reconnected to the web. It also provides a feature that allows an academic or student to trigger an inaccessible flag even though an eformat may have already undergone a check but is for some reason still

inaccessible to the user. This prevents the academic publisher from undertaking the barest minimum to make an eformat accessible.

Both the HEI library, academic publisher's and academic aggregator's version of the web application provide a means to produce an accessibility report and to control the verbosity of the report itself (Ulltveit-Moe et al., 2008). For example, this uses the instrument and metric automatic BW success criteria to measure the accessibility support of the HEI library web portal and the academic or student web application when reading eformats. Two possible variations would need to be tested, as to whether the accessibility evaluation tool should be incorporated within these applications or whether it should be provided as a separate application in its own right.

The HEI library version of the web application also provides the means to alter DRM restrictions to certain encrypted eformats but would require a specific licence from the publisher for educational purposes only. Blass and Rothlauf refer to this in terms of unilateral agreements between vendors (Bläsi and Rothlauf, 2013). Once the institute library intervenes in terms of altering a DRM restriction, the academic or student can be notified along with the academic publisher simultaneously. This addresses the issue identified during Expert Review Two, whereby DRM restrictions can be viewed by the user as required.

8.3.1 Justification for the four web applications and a web service

There were two main reasons why four web applications and a web service were required. Firstly, the published research findings indicated eight potential stakeholders within academic and non-academic domains. Since, as has already been established, the non-academic domain was beyond the scope of this thesis the four stakeholders within the academic domain remained and were chosen. The academic and the student may both require the use of an HEI library web portal on a mobile device. HEI libraries are enable academic or student users' access through authentication credentials to copyrighted material on external servers. These include academic publishers and academic aggregators who make provision for HE material such as ejournals and electronic academic literature. Examples of academic publishers include SAGE and

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Elsevier, whereas academic aggregators might include EBSCOhost and INGENTA. In referring to these companies it does not imply endorsement.

Secondly, the developer referred to at the beginning of this chapter, stated that to have one web application that covered all the requirements of the four stakeholders would be unwieldy to code. The developer therefore recommended separate API centric web applications specific to each stakeholder with an overarching web service. In this context the developer also suggested that an iterative approach to development should be undertaken. The reason for this was so that each stage could be evaluated and changes made as required.

The full written specification and wireframe designed by the researcher was based on the automatic BW success criteria generated by the instrument. The instrument integrated the four new framework components as derived from Chapter 7. The specification required the researcher to brief a developer at the University of Southampton who was employed by an industrial partner. The role of the developer was to establish realistic stages of development using the full specification and wireframe with oversight from the researcher. It was quickly determined that an iterative process would be required for development based on the full specification and wireframe. Three stages were identified in order to develop the first stage of the first web application, the following was required:

1. Testing that accessibility metadata could be extracted from a PDF format using a web service forming the proof of concept tool. The reason the PDF was chosen is because the published research findings indicated that this format was the most predominantly used in HEI libraries.
2. To focus on the HEI librarian web application by establishing exactly what this application needed to do in relation to the existing HEI library system.
3. Integrating the device.

Evidence of the developer's feedback on the process was provided in the form of personal correspondence on the 28/08/2018, and subsequently on the 15/04/2019. Each correspondence occurred after a meeting between the developer and the researcher and only on these two occasions. The reason for this was that the iterative development is an ongoing process.

The developer stated that the service is a web application plus a JavaScript (JS) library. The web service includes a dashboard for the HEI librarian to process PDFs and/or EPUB3s. The service will use a JS plugin that will be embedded into the existing library website using API credentials. No PDFs or EPUB3 formats will need to be uploaded or downloaded from servers since this is a data to data service that uses data streams.

The PDF and EPUB3 formats are interrogated by the service that can be used as a standalone service or as a service to scrape the etext formats on the HEI library, academic publishers, and/or academic aggregator's server given permissions by the library. The standalone service requires the HEI library to send multiple PDF and EPUB3 data streams. Each PDF and EPUB3 analysed will take approximately 30 seconds to one minute to process. The following diagram, see Figure 27, provides an overview of the interaction between the service and the existing HEI Library system. The diagram highlights a gap in that the HEI library need to decide which option will work best for their current system.

Once the accessibility metadata is extracted the developer stated that it would need to be presented in a form appropriate to the stakeholder and to determine how the accessibility metadata would be used. For example, if an etext, whether PDF or EPUB3, has 275 pages with 55 images that have 35 images without alt-text but 20 with alt-text is this document accessible? The provision of accessibility metadata in a stakeholder appropriate form confirmed the findings of Expert Review Two and the features already made available in the wireframe.

The developer confirmed that the proof of concept tool demonstrates that 'accessibility metadata can be extracted' from a PDF using a web service. However, the developer did state that this was 'limited due to the current existing program libraries'. This corroborates the findings of determining the PDF and EPUB3 accessibility metadata programmatically.

The developer maintains that the web application integrating this 'service could also contribute to a global database for PDF accessibility metadata'. This would be inline with the assertion made by Whitehouse about a single global repository for accessible etexts (Whitehouse, 2011).

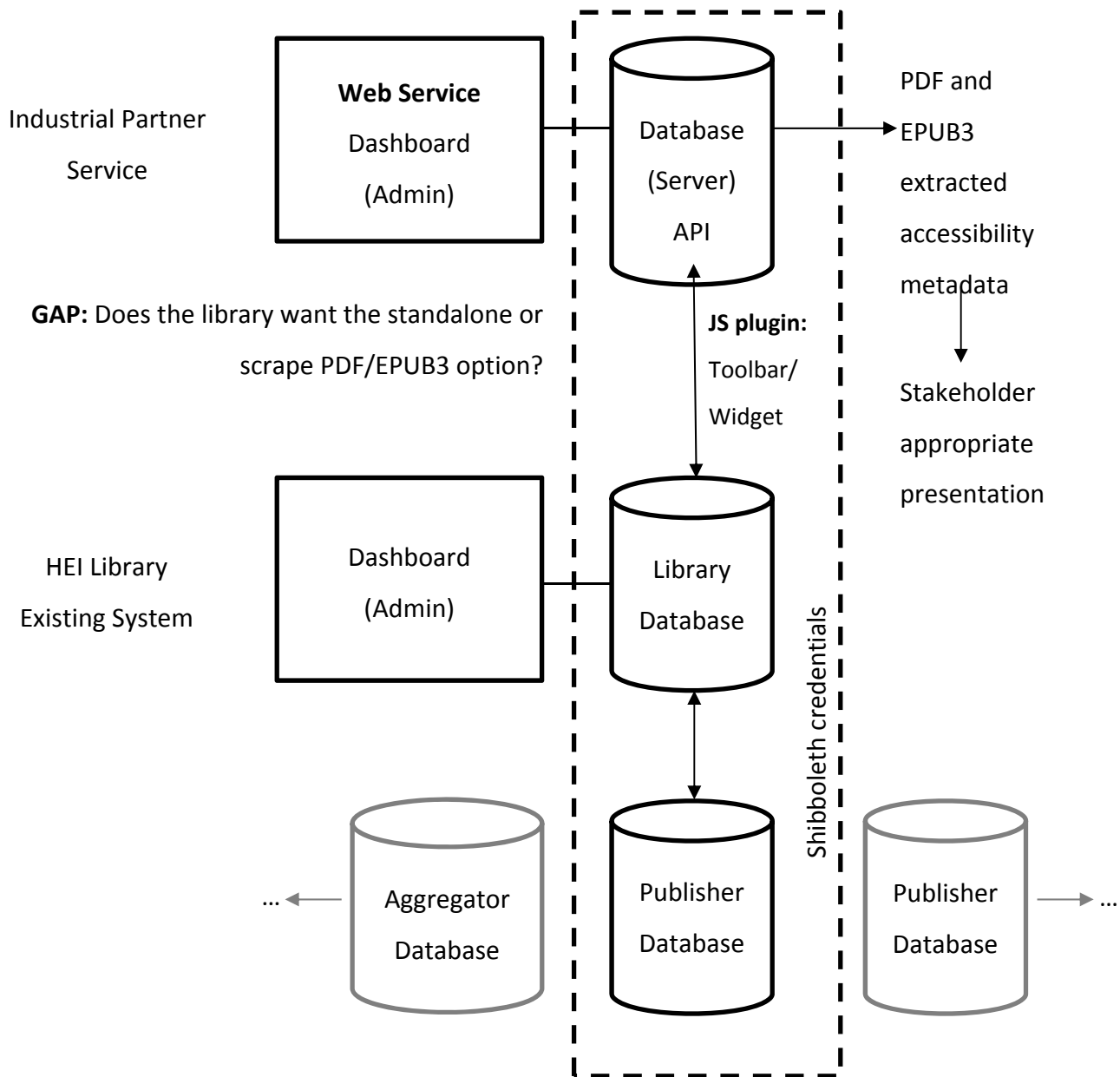


Figure 27: Service interaction with the existing HEI library system.

The proof of concept tool was also deemed to be the first iteration of the mobile web accessibility evaluation tool that could be incorporated into the four stakeholder specific web applications in the future.

The developer suggested too that the accessibility metadata 'could be both human readable and machine readable if we could convert from JSON to JSON-LD or other Linked Data versions'. The developer also stated that the web service 'could be further developed to extract multiple PDF documents and store the accessibility metadata in a

local database or develop a mobile ereader application based on the accessibility metadata’.

Although the first application chosen for development was aimed at the HEI librarian, the developer stated that ‘it could also be used as a model integrated into other web applications used by:

1. Academics/students;
2. Academic publishers; and
3. Academic aggregators’.

The developer stated too that if the HEI library does not have an API, the standalone service will be able to provide an Open Source API.

According to the developer the service could be tested on an institute, academics, or student’s mobile device to determine the availability of device and UA accessibility settings. It could also be used to detect available storage on the device and if applications like Dropbox or Google Drive are available to store PDFs and EPUB3s. In the future the service could be incorporated into a bespoke ereader. The researcher is willing to test the web application on a personal Android device and to give permissions when downloading the service. The reason for this is that it would provide a chance to ascertain what information can be gathered in terms of device and UA accessibility features and settings.

The impact of the web service and stakeholder specific web applications was that they overcame the problem of inaccessible HEI library web portals, mobile devices, UAs and etext formats in four main ways.

Firstly, and most importantly, the mobile web accessibility evaluation tool incorporated into the stakeholder appropriate web applications prevents isolated accessibility evaluation across the HEI library mobile web ecosystem. This includes the HEI library web portals, mobile devices, UAs and etext formats. The four web applications enable stakeholders to evaluate each component of the framework automatically using the instrument automatic BW success criteria and to then feed that data into a web service. The other benefit to this web service is that it can run alongside a mobile web accessibility guideline repository that can be updated without impacting the web service

itself. Arrue et al used a similar architecture for automatic mobile web accessibility evaluation (Arrue et al., 2007).

Secondly, one significant requirement emphasised by McNaught is the need for publishers to be able to see the demand for accessible econtent in tangible figures (McNaught, 2016b). The web service enables the delivery of these statistics showing demand for this service in real-time, and it would also be able to aid academic publishers and academic aggregators in determining the priority for addressing that demand. The service allows academic publishers and academic aggregators to see what type of errors occur, since the user can trigger an inaccessible flag. Remedial action can then be taken by the academic publisher and the HEI librarian as required. It also enables HEI librarians, academic publishers and academic aggregators to manage their digital accessibility in house.

Thirdly, as a result of Expert Review Two it was found that stakeholders did not need to have an expert level of understanding. For example, the user maybe aware that they need to alter font size or adjust text colour, but may not be aware that this relates to accessibility. The interfaces too for each web application have been simplified allowing for easy interactions such as providing an inaccessible flag and to provide an accompanying qualitative comment. This allows the academic or student to state what problem they are having, not necessarily in technical terms, but in everyday terms. This allows a negotiation to take place between stakeholders, in that an HEI librarian does not need to know the technical language of academic publisher or academic aggregator and vice versa in order to address the print impairment needs of the academic or student user. In doing so this provides a common language between stakeholders.

Within the respective web applications for each stakeholder, links to information documents relating to accessibility were made available through the web service. In addition to this strategies made available through Lexdis and other similar projects have been integrated into the wireframe for each web application. In addition to this producing the wireframe indicated the need for an HEI librarian to redirect an inaccessible format to automatic conversion software such as Sensus-Access (Christensen and Stevns, 2017); but in subsequent releases the web application would allow academics

or students to send inaccessible formats directly to Sensus-Access rather than online or by email.

Complex documents that cannot be handled by Sensus-Access would then be automatically redirected to RNIB Bookshare, where accessibility specialists would be able to intervene manually. This would include documents that require STEM accessibility through languages such as MathML or ChemML as suggested by Garrish (2012), or for musical scores. Complex legacy documents that require scanning, and that may not be structured, can be flagged as being inaccessible and that alt-formats would need to be dealt with manually rather than by an automatic tool.

Finally, there is a distinct advantage with the features only available through web applications. For example, according to the developer the text and background colour of a web application can be altered for menu items without restarting the application. This would enable high contrast on all navigational menus, such as yellow text on a black background. In addition to this, it would provide customisation of text and background colours, such as for dyslexia accessibility requirements namely dark blue text on a light blue background. These settings could be stored and used generically across the four web applications as themes, so that on further logins to the application the settings are personalised. This would be in addition to being able to alter text and background colour within the academic or student application that allows ereading.

8.3.2 Limitations

The only foreseeable limitation will be that the four web applications combined with the web service will take time to develop.

8.4 Summary

Two main outcomes were achieved by producing a specification and wireframe that were based on the instrument automatic BW success criteria. Firstly, the potential for stakeholder interaction that requires a common language and the means to flag and deal with inaccessible econtent using a web service and four separate web applications.

Secondly, the service provided will also enable the demand for accessible publications to

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be determined in real time, providing tangible results to the academic publishing and academic aggregation sectors. In doing so this information will provide invaluable insight to the decision makers in these sectors enabling the accessibility requirements of the print impaired academic and student communities they serve to be met.

Another outcome was the realisation that the instrument and metric served multiple purposes. In that the automatic BW success criteria it generated could be used to create a mobile web accessibility evaluation tool. That evaluation tool, when used by developers and designers could then be used in the development lifecycle of an HEI library web application. It could also be used during the development lifecycle of its counterpart web applications for academic publishers, academic aggregators and print impaired academic or student users.

The specification was written and then checked with a developer at the University of Southampton who was able to help the researcher determine the essential items for the first iteration of the service as a proof of concept tool. This tool currently allows a user to evaluate a PDF for accessibility metadata and to view that metadata in a human readable form. It currently allows a PDF to be dragged manually into the application, but it can be setup to automatically evaluate the available accessibility metadata of multiple PDFs. The evaluations can then be logged and stored in a web service database or library. This library would be separate to the web applications as suggested by Arrue et al. (2007).

If the webs service and the four mobile web applications are developed by the same company this provides the potential for a powerful tool that enables device, mobile browser and ereader applications to communicate with each other. It also means that third party ereaders such as VoiceDream could be integrated into this ecosystem as long as this is achieved through the use of an API.

Chapter 9 Conclusion and future work

Embracing a fully user centred approach (Clegg-Vinell et al., 2014) to automatically evaluate mobile web accessibility, according to Bandeira et al, is not straightforward (Bandeira et al., 2010). This is epitomised in the multi staged process of accessing an HEI library web portal on a mobile device as specified by McNaught et al. (2010). For example, searching for, finding, downloading, navigating and reading digital content that meets the accessibility requirements of those with print impairments.

The outcome of this research demonstrates that across this entire ecosystem a single master key component, referred to as accessibility metadata has the unique ability to unlock hidden digital information in human readable form. This information enables the user to be able to determine if, for example, a PDF will meet their accessibility requirements prior to downloading it from an academic publisher and academic aggregator onto their mobile device. In order to achieve automatic evaluation for this, physical and sensory control categories were required for the mobile device. Since this was achieved it integrates mobile device characteristics and is inline with research undertaken by Vigo et al. (2008). It was for this reason that this thesis investigates how to automatically evaluate the mobile web accessibility of Higher Education electronic texts for those with print impairments. This is achieved by answering two research questions, namely RQ1 and RQ2.

RQ1 determines what the physical and sensory control categories are for those with print impairments and incorporates accessibility requirements for dyslexia, a type of cognitive impairment. The outcome of the control categories against the user tasks relevant to the mobile web HE etext ecosystem for print impairments forms the basis for answering RQ2. Through the use of accessibility metadata the latter provides the success criteria for the design and specification of an accessibility evaluation tool. This tool measures the accessibility support provided by mobile devices, mobile web browsers, mobile web content, mobile web ereader applications and downloadable formats such as a PDF and EPUB3. Both RQ1 and RQ2 require the use of expert review to help determine what the control categories are and to evaluate whether the instrument works in the specified HEI

library ecosystem. The use of automatic mobile web accessibility evaluation has the potential to ultimately lead to personalisation within the HEI library mobile web ecosystem.

9.1 Research contribution

The main research contribution this thesis provides is a strong rationale for why accessibility metadata is essential across the entire HEI library mobile web ecosystem that includes mobile devices, mobile browsers, and UA ereaders and etext formats. It also emphasises a crucial aspect of the instrument in that it identifies the gaps where accessibility metadata are still required and the need for future development. If no accessibility metadata or API's are currently available a mapping to WCAG 2.0, UAAG 2.0, EN 301 549 and ETSI EG 203 350 for expected outcomes were provided for this future development. It also provides existing accessibility metadata and API accessibility support relevant to the HEI library mobile web ecosystem. This overall research contribution relates to RQ2, however, RQ2 could not be answered until an answer for RQ1 was determined.

9.1.1 Answering Research Question One

Research question one (RQ1) states: what physical and sensory control categories support automatically evaluating the mobile web accessibility of Higher Education electronic texts for print impairments? Four physical and sensory control categories were determined when undertaking Expert Review One for print impairments, namely:

1. Navigation;
2. Viewing the screen;
3. Audio (including alternative access, such as TTS); and
4. Voice recognition.

Since navigation had already been discussed as being defined as touch, the above list was rationalised for use in the instrument in the following way:

1. Visual controls;

2. Touch controls;
3. Audible controls; and
4. Voice controls.

This final list also took into account the occurrence of accessibility features across three mainstream smartphone devices and 12 ereader applications, four mobile browsers and four online reader applications combined.

There was, however, a caveat in that audible controls are grouped by the individual experts with alternative access controls such as TTS, an accessibility feature that is predominantly used by those with dyslexia. If alternative access was separated out into an additional category, referred to as cognitive controls, it would increase the complexity of the instrument and may impact adoption by stakeholders as referred to by Vigo and Brajnik (2011). The other alternative required the integration of cognitive controls using a combination of the physical and sensory control categories. This also reduced the complexity of the instrument and may aid the adoption by stakeholders but was more complex to implement. The latter approach was taken for this thesis since only four features were identified in UAs that provided simplification, namely:

1. Altering layout by increasing or decreasing white space;
2. Decluttering by providing a full screen option;
3. Simplification by offering easy to understand synonyms; and
4. Read along, whereby text can be read on screen, with highlighted words that are read out aloud.

Expert Review One was undertaken to answer RQ1 and was fully discussed in Chapter Four of this thesis. Alongside Expert Review One, a device and UA occurrence of accessibility features was also undertaken. This was achieved through a physical assessment (Whitehouse, 2011) of mobile device and UA settings, by mapping the core device settings related to accessibility for an Android, Windows and iOS smartphone device. The Windows phone 8.1, at the time of writing, did not support accessibility features for motor impairments, such as switch control, allowing a user to navigate through menus and etexts by tapping a switch device or key on an external keyboard. Similarly, mappings between core UA settings were also undertaken for mobile browsers

and ereader applications. Once completed these were then mapped to WCAG 2.0 where possible. The grouping of device settings in conjunction with the mapping to WCAG 2.0 aided the removal of non essential settings that did not relate to accessibility.

RQ1 determined what the physical and sensory control categories were for those with print impairments, so that device and UA accessibility features could be categorised within the instrument alongside their input and output functionality. The automatic BW success criteria generated by the instrument was used as a means to write the specification for an accessibility evaluation tool that could then be incorporated within the four separate web applications.

9.1.2 Reflecting the mapping of the existing accessibility metadata to the framework

Table 36: Mapping examples of existing accessibility metadata to the framework.

EXISTING ACCESSIBILITY METADATA	FRAMEWORK
HTML/HTML5/CSS/JAVASCRIPT etc. Tags relating to the accessibility of the: 1. Institute Authentication - Institute Library; 2. Institute Portal Steps - Institute Library; 3. Search 1 & Search 1 Result(s) - eg. Web of Science search; 4. Search 2 & Search 2 Result(s) - Academic publisher's website; 5. Preview Paper Abstract - Academic publisher's website; 6. View Accessibility Metadata Prior to Download - Academic publisher's website.	Discovery

Table 36 continued.	
EXISTING ACCESSIBILITY METADATA	FRAMEWORK
PDF: Accessibility metadata tags relating to: 1. Fast Web View (eg. Linearize); 2. Accessibility permission flag is set (eg. allows the user to copy and paste text); 3. Accessibility report attached to document; 4. Document is tagged PDF; 5. Custom Properties. EPUB3: 1. IDPF: Accessibility Summary (eg. contains MathML etc.) 2. Onix Code 10: No reading system accessibility options disabled. 3. Onix Code 99: Publisher contact for further accessibility information	Econtent Format
HTML/HTML5/CSS/Javascript and Device API tags for available applications that manage storage, including ereader applications, relating respectively to: 1. Search 2 Result - Publishers website. 2. Manage Downloads (includes Digital Rights Management (DRM) protected formats) – eg. Adobe Digital Editions (ADE) or an ereader created by the industrial partner. 3. Third Party Storage – eg. Dropbox, Google Drive, DataAnywhere etc.	Download

Table 36 continued.	
EXISTING ACCESSIBILITY METADATA	FRAMEWORK
Device API tags for available ereader applications and Industrial partner web application that allows ereading and an API for third party ereaders relating to: 1. Authentication & Synchronisation; 2. View Format Metadata in UA; 3. Help pages; 4. Import etext, library (etext shelf) & Library Search; 5. Manage Local Downloads & Third Party Storage access within the UA; 6. Plugin Usage (eg. The Gitden Reader has a PDF plugin app); 7. Document View & Screen Orientation; 8. Manage Bookmarks & Links Menu; 9. Progression & Lookup; 10. Search etext.	UA Ereader

The instrument analyses the four physical and sensory control categories for the device and the mobile browser, incorporating issues arising for dyslexia, against the four framework components. The framework also integrated device characteristics, inline with Vigo et al. (2008), and helps to address the now 10 year old MWBP 1.0, a call made by Kaur and Dani (2017). Table 36 maps, in total 27, a representative example of the existing accessibility metadata to the framework. The representative examples have been prioritised as being the most important out of a possible 66 mappings for the four framework components.

Table 37 also provides a mapping of, in total 17, representative examples of device and mobile browser accessibility features categorised by the physical and sensory control categories to the framework. This incorporates issues arising for dyslexia such as synonyms on demand and Read Along using media overlays.

Table 37: Physical and sensory control category features mapped against the device component of the framework. Continues next page.

EXISTING ACCESSIBILITY METADATA	FRAMEWORK
Visual Controls: Accessibility metadata relating to: 1. High contrast/colour inversion (eg. The accessibility metadata tag: ACCESSIBILITY_DISPLAY_INVERSION_ENABLED for Android); 2. Themes; 3. Colour filters; 4. Font style; 5. Layout (white space) (eg. Margin for Android); and 6. Declutter (eg. Full screen); 7. Simplification (eg. synonyms on demand and read along). 8. Text/font size (eg. android:textSize)*; 9. Zoom/magnification*; 10. Reflow (includes responsive web content using media queries).	Device (includes mobile browser CSS support when indicated with an asterisk).

Table 37 continued.	
EXISTING ACCESSIBILITY METADATA	FRAMEWORK
Touch Controls: Accessibility metadata relating to: 1. Device gesture (eg. moving focus using a screen reader); 2. Hardware (eg. Volume button to turn page, Braille Display, Bluetooth keyboard, switch access control, haptic feedback); 3. Onscreen keyboard; 4. Screen orientation.	Device (includes mobile browser CSS support when indicated with an asterisk).
Audible Controls: Accessibility metadata relating to: 1. Screen reader; 2. Text to Speech (pending mobile browser API*).	
Voice Controls: Accessibility metadata relating to: 1. Voice recognition (eg. In the mobile browser* or when using the onscreen keyboard).	

The analysis of the four framework components against the physical and sensory control categories for the device resulted in over 400 BW success criteria that require automatic accessibility evaluation. Each of these success criteria were mapped against WCAG 2.0.

9.1.3 How this supports automatic evaluation

Since there are over 400 BW accessibility success criteria that can be automatically evaluated the following provides an overview. It includes examples from each of the four

control categories and how these are analysed against the four framework components by supporting automatic evaluation of the BW success criteria. The Visual Control category uses the example of the device API and mobile browser CSS support for Text/Font Size. The touch controls use the example of the screen reader being used for navigational purposes by moving focus. The audible controls, again use the example of a screen reader but for audible output. Voice controls use the example of voice recognition when using the mobile browser search box or address bar. In addition to this the automatic evaluation of UA ereaders is covered separately alongside how the instrument indicates gaps for the development of future API accessibility metadata.

Visual controls were previously indicated in Table 36 providing examples of 10 accessibility metadata tags. One of these tags relates to the text/font size API for devices and mobile browser CSS support. This was mapped to SC 1.4.4 Resize Text Level AA (WCAG 2.0) and was deliberately chosen because, at the time of writing, it was supported across all three mainstream mobile devices, namely iOS, Android and Windows. The CSS for text/font size is supported by the cross platform mobile browsers Chrome, Firefox and Opera.

The user can also customise the text/font size within the accessibility settings of the mobile browser itself. It may be possible for the programming language used for the mobile browsers to be interrogated to determine if these accessibility features are available. For example, Objective-C is used for iOS, and Java for Android. The iOS platform provides dynamic text size. This feature enables the user to set the text/font size once on the device and for mobile websites subsequently visited to have their text size altered according to this OS setting. It does, however, rely on a website being coded correctly. This provides a lead on how the devices text/font size can be automatically evaluated when analysed against each of the first three framework components.

The automatic accessibility evaluation tool does two things simultaneously. Firstly, if permissions are given, for example, by the academic or student the accessibility evaluation tool automatically determines the devices text size capabilities using the devices API.

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This can be explained to academics and students at registration or for first time use whether institute device or BYOD policies are in play. This is not about determining usage, it relates to whether the device and mobile browser accessibility settings are available. However, if device permissions are given when the application is downloaded, on device usage, via user behaviour analytics, can be determined as well and would provide useful research data. The outcome of this takes the form of a data stream and is sent to the web service. For example, the device accessibility API for text/font size is 'pointSize' for iOS, 'android:textSize' for Android and 'TextScaleFactor' for the Windows phone.

If, however, device setting permissions are not given the device type and OS version can be determined without permissions required. This can then be automatically compared to the regularly updated GARI database that can be downloaded under a Creative Commons License. The GARI database identifies mobile devices with APIs. Vigo et al use a similar approach by basing automatic mobile device web accessibility evaluation on device and UA description repositories (Vigo et al., 2008). This database, however, relies on third party manufacturers and vendors to provide information about their devices and/or UAs. There is no guarantee that this information is accurate or reliable. The GARI website also does not specify what accessibility standards and/or guidelines it uses.

The mobile browser type and version can also be determined without requiring permissions and can be compared automatically with the 'Can I Use' repository for mobile browsers. For example, the Full Screen API is currently supported by Firefox for Android and partially supported for both Chrome and Opera for Android. Whereas, at the time of writing only Chrome for Android and Firefox for Android supported this core accessibility feature.

Secondly, the web application for the HEI librarian or academic publisher or academic aggregator can incorporate an existing web accessibility API, such as that offered by Tingtun, to automatically evaluate the tasks (steps) the academic or student is required to undertake during Discovery. In this instance it would be specific to checking text/font size web accessibility issues on both the HEI library web portal, the academic publisher's/academic aggregator's website and for checking mobile browser compatibility with the most current CSS.

Alternatively a bespoke web accessibility component of the tool would need to be developed based on the automatic BW success criteria indicated by the instrument. Using either approach, the HEI librarian or academic publisher or academic aggregator would be able to automatically evaluate the HEI library mobile web portal and the academic publisher's or academic aggregator's website respectively. Again this would take the form of a data stream that is then sent to the web service. The combined data streams would allow the HEI library and/or academic publisher or academic aggregator to intervene if required. Alternatively the academic or student web application will notify the user if text size is available on the HEI website. It will also do the same if the HEI website supports the device OS feature for dynamic text size. Dynamic text size does not necessarily get activated by default on the mobile device and the user may not be aware of its availability. In addition to this it would also provide a solution if the website is not responsive.

The econtent format accessibility metadata, for text/font size, can also be automatically extracted from both PDF and EPUB3 formats by the academic publisher or academic aggregator or the HEI library. This is achieved by either parties sending a raw format data stream to the automatic accessibility evaluation tool. Alternatively the HEI library would need to provide access to the academic publisher's or academic aggregator's servers, and any special collections held in-house, through authentication credentials to allow the accessibility evaluation tool to scrape the PDF and EPUB3 formats available.

This then updates the web service and the information can then be made humanly readable on both the HEI library mobile web portal and the publisher's or academic aggregator's website, if required, since these are both steps included during Discovery. It can also be made humanly readable within the academic or students web application. Generally the EPUB3 is more flexible with text size but if a PDF is PDF/UA compliant it can be made to reflow and be resized using device gestures in Adobe Reader. The other reason it is important to be able to extract text size metadata from a PDF is that the text within a PDF can be scraped and then redisplayed. This is how the VoiceDream Reader enables PDFs to be redisplayed on screen.

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The automatic extraction of accessibility metadata from a PDF and/or EPUB3 is a form of meta accessibility evaluation. It provides a means for the HEI Library to determine if the academic publisher or academic aggregator has already undertaken an accessibility evaluation on the format and to what extent. This also guards against the academic publisher or academic aggregator from doing the barest minimum. If no accessibility metadata is available in the format, remedial action can be taken whether it is the fault of the academic publisher or the academic aggregator overwriting accessibility metadata.

Another option is to develop a component of the automatic accessibility evaluation tool that has a bespoke means of fully evaluating the PDF and EPUB3 formats. This would be a considerable undertaking considering that the PAC3 and PAVE 2.0 tools for PDF and the ACE tool for EPUB3 are already available. Alternatively, it may be possible to use APIs with these services if they become available.

The download accessibility metadata for text/font size would relate to automatically evaluating both the web accessibility of the academic publisher's or academic aggregator's website and device APIs for determining what applications and system storage are available on the device. The text/font size of the download link would be automatically evaluated by checking the CSS of the publisher's website. In turn the text/font size setting availability would be determined in three ways for the relevant applications, whether it is for:

1. The ereaders download management menus;
2. The third party storage application, such as Dropbox or Google Drive; and
3. The devices download management menus.

The ereader and third party storage applications would need to recognise the device system settings for text/font size using the appropriate device API. If, however, the ereaders are unable to do so a notification, on first use, will need to be provided to the user to locate text/size settings within the respective applications. The accessibility evaluation tool will need to be able to detect if API calls are being made by third party applications. If this is not detected then it is unlikely the API features for text/font size are being used. This could then be reinforced by ereader application data available from a repositories such as Epubtest.org or from GARI.

The Touch Control for device gestures, previously indicated in Table 36, is now discussed in relation to the first three framework components. In this instance, the automatic evaluation is specific to moving focus using the devices screen reader, a core accessibility feature. This is deliberately chosen to distinguish between using touch (input) for screen reading purposes, specific to navigation, as opposed to audible output.

In terms of Discovery the accessibility evaluation tool tests each task (step) undertaken by the academic or student that is specific to the use of touch. This was mapped to S.C 2.4.7 Focus Visible Level AA (WCAG 2.0). For example, each step during Discovery requires that the academic or student can move focus through the use of the screen reader while searching for, finding and navigating to the required etext. This can be automatically evaluated using the tool by checking the HTML/HTML5 and CSS tags against S.C 2.4.7. Another important aspect of this automatic web accessibility evaluation is to test the focus navigation of a PDF when presented online through a web browser.

The econtent format accessibility metadata enables the automatic evaluation tool to determine if focus can be moved through the semantic structure of the PDF or EPUB3. For example, if a PDF is tagged this enables the screen reader focus to be moved sequentially through its content.

The download accessibility metadata determines whether the focus using a screen reader can be moved to the download link of the etext format, on an academic publisher's or academic aggregator's website. It is also determines if focus can be moved from the mobile browser, to the UA ereader and to the device as required.

The audible controls for the screen reader audible output, previously indicated in Table 36, are now discussed in relation to the first three framework components. This accessibility metadata would be specific to the device API's relating to the audible options available within the devices screen reader and again the use of web accessibility criteria.

In terms of Discovery the automatic accessibility evaluation tool would undertake web accessibility tests on each step undertaken by the academic or student during Discovery specific to whether the devices screen reader would be able to read aloud this content.

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For example, this would be specific to testing against S.C 1.3.1 Information and relationships Level A (WCAG 2.0).

Similarly, the econtent format accessibility metadata enables the accessibility evaluation tool to determine if the devices screen reader can read aloud the content of the format. For example, if a PDF has its accessibility permission flag set this allows the user to copy and paste text. If this is possible it also means that the screen reader will be able read aloud the text available in the PDF document.

The download accessibility metadata again relating to web accessibility and device API's enables the automatic accessibility evaluation tool to determine if the screen reader can read aloud content. This would be for both the academic publishers download link and the third party ereader and storage applications. Again this would require the vendors for these applications to make use of device APIs. If these are not available, as with the touch controls, then a contingency would be to use the epubtest.org or GARI repositories.

The Voice control accessibility feature for voice recognition, indicated previously in Table 36, is now discussed in relation to the first three framework components. In this instance the device API's for voice recognition and automatic evaluation against S.C 1.3.1 Level A (WCAG 2.0).

In terms of Discovery each step undertaken by the academic or student is evaluated particularly where voice input is required, for example when providing a search string in a search box. The device API for the onscreen keyboard feature that allows the use of voice recognition would also be automatically evaluated.

The econtent format and download accessibility evaluation metadata for voice recognition is currently not available and would be a potential area for future accessibility metadata development. In terms of the econtent format, this has the potential for searching, navigating and annotating an etext by voice alone through the device.

The automatic evaluation of the UA Ereader is discussed separately at this stage. The reason for this is that it is currently not possible to automatically evaluate third party ereader applications. It would be possible if an API is provided within the automatic accessibility evaluation tool but would rely on vendors subscribing to its use. One of the

key reasons why it is important to be able to automatically evaluate the mobile web accessibility of ereader applications is to determine if the accessibility metadata is made humanly readable. Tools such as the SSB BART Accessibility Management Platform (AMP) evaluation tool can be used by developers when developing mobile applications, such as UA ereaders. It is more likely, however, that the developers when developing the web applications for the respective stakeholders would use the developer's accessibility tools built into for example to the Google Chrome browser and device emulator.

Another important reason why ereader applications need to be automatically evaluated is they may provide additional accessibility features that are not currently possible on the mobile device or within the mobile browser. For example, the IDEAL Group Reader, Text4All and DysWebxia ereader applications provide synonyms on demand. Synonyms on demand are not currently supported in device APIs or in mobile browsers.

9.1.4 Answering Research Question Two

Research question two (RQ2) states: How does the mobile web accessibility of Higher Education electronic texts for print impairments need to be automatically evaluated? Chapter six discusses the development of the instrument and metric in detail, with particular emphasis on Expert Review Two. The instrument provides the success criteria that answers RQ2. Chapter seven indicates, through the use of API calls, how to programmatically detect the accessibility metadata of three main components of the framework:

1. The accessibility metadata of a PDF and EPUB3;
2. Device settings across three mainstream platforms, namely the iOS, Android and Windows smartphones; and
3. Three cross platform mobile browsers, namely Chrome, Firefox and Opera.

The accessibility settings available to ereader applications would be tested by running the accessibility evaluation tool during the design and development stages. Chapter six further supports answering RQ2 by providing a barrier walkthrough in the form of a high fidelity prototype that exposes accessibility metadata prior to downloading a PDF format from an academic publisher's website. The barrier walkthrough provides a step by step

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guide of the entire process from discovery, using an HE web portal on a mobile device, through to a print impaired user navigating and reading an etext in an ereader application. Expert Review Two required individual expert participants to undertake the walkthrough using the Invision prototype tool and to then evaluate the prototype using the automatic BW success criteria. The main outcome was that the prototype and walkthrough worked on an HEI library mobile web portal, although further analysis is necessary.

Although 8 expert participants were involved in Expert Review Two, meeting the minimum requirement as specified by Hwang and Salvendy (2010), the results were adversely affected. This was because only seven participants answered the question about whether the instrument automatic BW success criteria would work on an HEI library mobile web portal. In addition to this, only four expert participants answered a similar question for an academic publisher's website. This was due in part to either a lack of clarity in the writing of the questions or the time the individual experts were able to give to the review.

Two important outcomes were discovered during this stage of the research. Firstly, according to Lemon colour contrast levels cannot currently be automatically evaluated on mobile devices (Lemon, 2017). In the Adobe Acrobat XI Pro Accessibility Guide for PDF accessibility best practice it also states that colour contrast and reading order require manual checks (Adobe, 2012). In a personal communication with the researcher, Juicy Studio state that actual screen colour combinations need to be inputted manually into a colour contrast analyser tool. Lemon also does not recommend the use of screenshots as this approach is not accurate (Lemon, 2017). This is in contrast to the BBC mobile accessibility guidelines (BBC, 2017). Automatic mobile web accessibility evaluation can, however, detect high contrast and colour contrast feature availability for mobile device settings, mobile ereader applications and mobile browsers, if available.

Secondly, the econtent component of the framework can be subsumed into the format component. For example, semantic structure of a document can be determined by interrogating heading metadata, such as H1 to H6 in the PDF format. This reduces the complexity of the instrument and may improve stakeholder adoption an issue identified

by Vigo and Brajnik (2011). Automatic evaluation can have as many success criteria as required but this will require verbosity control on the audit report a requirement suggested by Ulltveit-Moe et al. (2008).

9.2 Relationship of Expert Review One findings with previous published research findings

Since the physical and sensory control categories plus the core device and UA settings are device centric, this not only achieves integration of device characteristics (Vigo et al., 2008) within the framework but also exceeds it. With the potential transition from institute devices to BYOD policies (Draffan et al., 2014), recognised categories across all devices would be advantageous, reducing the need for academics or students to upskill when using another device. This approach may improve the memorability, learnability and the usability (Nielsen, 1993) of accessibility settings by print impaired users across the HEI library mobile web ecosystem.

Another outcome is that the shortlisted device and UA settings, in combination with each other, meet the accessibility requirements of the majority of those with print impairments reading electronic texts within the mobile web accessibility HE domain as stated by McNaught et al. (2010). For example, Expert Review One indicated that simplification was as an accessibility requirement for users with dyslexia and corroborates Rello et al. (2013). This accessibility requirement, as a success criteria, incorporated from the outset in a specification for an accessibility evaluation tool would enable the design and development of future ereader applications, mobile browsers and device settings.

Within the published research findings similar variations in the use of terminology were found, but again pointing to a visual control category. For example, terms such as 'display' (Mi et al., 2014) and '*presentation control*' (Gylling and Herman, 2014) were used when categorising features relevant to accessibility on mobile devices and within ereader applications. Rello and Barbosa identified parameters that are visually based, specific to those with dyslexia requiring accessible text when using a reading tool, namely: font type, font size, font and background colour adjustment, and character spacing (Rello and Barbosa, 2013).

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Similarly 8 expert participants referred to an audio control category. Mi et al refer to an '*audio feedback*' control category (Mi et al., 2014). The WCAG 2.0 Success Criteria 1.4.2 refers directly to Audio Control (W3C, 2008).

Two expert reviewers referred directly to 'touch control' whereas two other terms were also referred to respectively by two other expert reviewers: 'options for touch' and 'navigation options'. The latter term was within the context of button size and options to use a pointer. This leads directly to input functionality and why navigation was defined in terms of touch. Touch control is again referred to directly in the published research findings. Mi et al, specify '*touch feedback*' as a control category and also refer to the term '*touch-operated controls*' (Mi et al., 2014). The ETSI guidelines refer directly to touch controls (ETSI, 2016).

The term '*tactile control*' is also referred to by Whitehouse (2011); whereas testing the operability of '*touch based gestures*' was also used by Clegg-Vinell et al. (2014). Three expert participants referred to 'voice recognition' as a control category and this term is reflected in the published research findings. Kaur and Dani refer to '*voice control functions*' (Kaur and Dani, 2017). WCAG 2.1 refers to input methods that are alternative such as 'voice' (W3C, 2018). These references confirm the use of the control category terms within the final physical and sensory control category shortlist.

Finally, three reviewers indirectly referred to what could be deemed to be a cognitive control category, but this was integrated into the instrument under alternative access and grouped by the experts alongside the audio control category. One expert referred to this category as 'Can I simplify what I am accessing'. The published research findings do not directly refer to this but do support the tenet of a cognitive control category, such as synonyms being presented on demand as stipulated by Rello and Barbosa (2013).

9.2.1 Expert Review One limitations

The main limitation for this review was that participants may have been distracted filling out the surveys during a break and networking. That being said it was the only time available in order to fill out the survey. In addition to this, the survey was undertaken by using hardcopy questionnaires and in some instances handwriting was difficult to read

during qualitative analysis. In order to alleviate this issue further data collection was undertaken on iSurvey, the University of Southampton's official data collection tool.

9.3 Relationship of Expert Review Two findings with previous published research findings

Four main suggestions were made by the individual experts regarding improvements to the instrument and metric. Firstly, the technical language used in the success criteria needs to be addressed so that a common language can be produced for all stakeholders in the domain. The manual crowdsourced evaluation undertaken by JISC and partnering universities, publishers and academic aggregators is currently developing this *lingua franca* as referred to by Dobson and McNaught (2017).

Secondly, even though the instrument provides success criteria for an automatic mobile web accessibility evaluation tool, the report produced by that tool would require verbosity control. In that a low level of granularity is required for the technical descriptions; whereas a high level of granularity is required for end user aggregated reports as recommended by Ulltveit-Moe et al. (2008). The report produced by the tool would also need to be in the aforementioned stakeholder language. However, for the expert review the heuristics that were evaluated had to be sufficiently detailed enough to expose accessibility and usability issues identified in the walkthrough and prototype as specified by Ferati and Beyene (2017).

Thirdly, one expert suggested that it would be interesting to find out more about the results gathered from a single website using the instrument. This could be taken further by providing not only an overall accessibility score for the entire ecosystem but for each component of it. For example, a scoring for the HEI library web portal, a separate scoring after handing off to the academic publisher's and academic aggregator's website, and additional accessibility support scoring for the ereader applications and the download onto mobile devices. Scoring for etextbook accessibility is evident in the published research findings as stated by Chan et al. (2017). One expert did highlight the issue of adding alternatives to the prototype and walkthrough for differing HIE library web portals. However, there is a caveat, according to Vigo and Brajnik that in order to make

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comparisons between different HEI library web portals that a finer-grained scale is required that reflects the accessibility status of a web page (Vigo and Brajnik, 2011). This means that there will be a constant interplay between high and low level granularity and why a web service with a separate repository (Arrue et al., 2007) to handle the amount of data gathered has been suggested in the discussions of chapters five and seven.

Finally, one expert also suggested that the second criteria for touch controls would need to incorporate switch access control. This was included in the final instrument, but not specified in the abridged version for the expert review. The abridged version was to reduce the time required to undertake the review, to minimise drop out. Not only would screen reader and switch access control need to be considered but also keyboard and gesture access. This is where all interactions require focus to be visible, and for a user with severe visual impairments to be able to locate focus through audible feedback within the browser as recommended by Richards et al. (2012).

Issues with the UI for the prototype, in particular redundancy of feature controls was also emphasised by one expert and discussed in more detail in chapter seven. Redundancy, however, according to Wechsung helps to reduce cognitive load experienced by the user (Wechsung, 2014) but this needs to be metered by simplification of the user interface as referred to by Newell (2011). For example, to only provide redundancy in strategic parts of the UI. This also relates to WCAG 2.0 SC 2.4.5 Multiple Ways – Level AA, in this instance that multiple pathways to mobile web content are provided. The primary purpose of the survey, however, was not to assess the UI but to determine whether the success criteria would work on an HEI library and academic publisher's web portal. By providing an abridged version of the instrument, aspects of it were flagged up by the individual experts that were covered in the specification and discussed fully in Chapter 7. For example, the accessibility evaluation tool provides the means for an academic to send an inaccessible document for conversion to an alt-format as specified by Christensen and Stevns (2017), or for a publisher to be able to flag up alternative formats directly to the institute version of the ereader application.

One expert suggested removing the criteria referring to character spacing, since different fonts have different character spacing intrinsic to their design. This relies heavily on the

availability of multiple fonts. However, evidence in the published research findings maintains that reading speed is significantly increased with increased character spacing (Rello and Baeza-Yates, 2017) and that a means to alter the spacing is an accessibility requirement (Rello and Barbosa, 2013) for those with print impairments.

Three aspects of the abridged instrument were thought to have been overlooked by the individual experts, these were items that had already been covered in the full version of the instrument. They included DRM access, improving navigation speed and efficiency, and help pages. The fact that the individual experts picked up on these aspects adds further validity to the unabridged version of the instrument.

According Bläsi and Rothlauf DRM restricts access to certain content and requires specific ereader applications to read the content (Bläsi and Rothlauf, 2013). DRM can prevent AT from also being able to access the content because permissions are set on the amount of text that can be copied and therefore read aloud as stated by Ellis and Kent (2011).

One of the experts flagged this and stated that information about the amount of text that could be copied needed to be stated clearly. The permissions flag was included on the instrument but information about the amount of text that could be copied needs to be included on future versions of the instrument.

Navigation speed and efficiency was also incorporated into the instrument by referring to progression and lookup. The W3C state that this includes the use of HTML regions on a webpage, skip links, skip to content and bypass blocks (W3C, 2018). The use too of headings, links, bookmarks, progression bars and table of contents were also included for eformats in both the Adobe best practice guidelines (Adobe, 2012) and the IDPF EPUB3 standard (IDPF, 2017). The efficiency of navigation also relates to usability (Garcia-Lopez et al., 2017). Help pages, such as those specified in WCAG 2.0 SC 3.3.5 Help - AAA, were included for the ereader applications in the instrument; but were not included for the HEI library web portal, and again would be required in future iterations of the instrument.

In terms of whether the instrument would work on an institute library portal three main suggestions were made by the individual experts. Firstly, provision needs to be made for accessibility ratings of publications and to include built in accessibility tools in ereader

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applications. Similar approaches have been undertaken for accessibility scoring on search engine results as evaluated by Vigo and Brajnik (2011). ATbar (UoS, 2011), a cross browser toolbar that provides AT, is an example of a built in accessibility tool that could operate on a mobile device in this context.

Secondly, the user experience of ebooks was highlighted by one expert, particularly whether a poor experience would be repeated. This is partially evident in the published research findings as stipulated by Ward et al that copyright and different access restrictions hinder a consistent user experience (Ward et al., 2015).

Finally, device usage, particularly that of desktop over mobile within HEI's. One expert stated that a desktop PC would be better to use rather than a mobile device for searching for, finding, downloading and reading etexts that meet accessibility requirements. Evidence suggests that 'notebook' computers are used more frequently for assignments (Cheung, 2015) but tablets are perceived to more useful when learning and that if a tablet is used then additional mobile technologies are included in learning strategies as indicated by Delcker J. et al. (2018). By focusing on the mobile device first, other platforms can be incorporated into the instrument in future iterations.

Evidence from the University of Southampton usage of the Blackboard platform enables device usage to be inferred, and this indicates that while the majority of desktops used the Windows operating system, the most widely used mobile platform was the iPhone in a single HEI (Deeprise, 2016). This was in part echoed by the data set provided by Statista maintaining that there was iOS dominance up until September 2015 but then Android regained this in December 2015.

In addition to this, features that were thought to be missing were included in the unabridged instrument. One expert stated that within this context it relates to 'user design elements such as plain English, not crowding pages, clear structure and page hierarchies'. Decluttering (Web2Access, 2018) and full screen (Mozilla, 2018) were included in the final instrument. One expert also identified that on a publishers website accessibility metadata was not exposed for etexts. The published research findings refer to the use of accessibility metadata for discovery, specifically search metadata that meets user requirements as emphasised by Beyene and Godwin (2018). It does not, however,

refer to its exposure on the publisher's portal, the mobile device, UA or its availability in formats such as PDFs and EPUB3's. Beyene et al maintain that metadata undergirds the HEI library ecosystem (Beyene, 2017).

Three main accessibility requirements for evaluating the mobile web accessibility of HE etexts for print impairments were identified during the expert review. Firstly, that both the institute portal and the etexts provided must be accessible to a print impaired academic or student users as specified by McNaught et al. (2010). The option too, that alternative formats must also be either made available on the academic publisher's and academic aggregator's portal or that provision is made to automatically convert inaccessible documents to alt-formats. Examples of automatic conversion that produce alt-formats within HE can be found in the use of software such as SCRIBE as spereferred to by Christensen et al. (2012). The flexibility and simplicity of RDTs in institute libraries also needs to be addressed as stipulated by Beyene (2016). Navarro-Molina state that the accessibility of scientific ejournal publishing platforms is limited (Navarro-Molina et al., 2018).

Secondly, the gap between the AT offered on mobile web applications (James et al., 2017) and the digital accessibility provided by academic publishers (Kasdorf, 2017) needs to be addressed with the use of accessibility metadata both on the publishers web portal and in their epublications.

Finally, the accessibility requirements specific to mapping accessibility features available on mobile web platforms to print impairments. For example, magnification and contrast (VI); reflow; clear navigation functionality/structure (Whitehouse, 2011); Colour adjustment (including font colour) (Rello and Barbosa, 2013); font size adjustment (Rello and Barbosa, 2013); TTS (OS Compatibility) (Rello and Barbosa, 2013); navigation menu positioning and serial '*word for word*' consumption of information (Williams and Hennig, 2014); and bookmarking as specified by Adobe (2012) and the IDPF (2017).

9.3.1 Expert Review Two limitations

Even though 8 expert participants were involved in the expert review evaluation, only seven answered the HEI librarian question and only four answered the question for the

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academic publisher's website. Both of these questions were critical for the entire analysis of Expert Review Two. Although appropriate wording was provided in the questionnaire, further pilots of the questionnaire may be required for future versions of the survey. In particular greater clarity is required for the two critical questions, namely:

1. On a scale of 1 to 5 do you agree that the tasks 1 - 3 work on your institute's library portal?
2. On a scale of 1 to 5 do you agree that the tasks 4 - 7 work on your academic publisher's website?

The questions related to both the walkthrough and the use of the prototype, as previously discussed in chapters seven and eight. It may, however, help to have the following wording next to each question, in addition to having it written at the beginning of the question section on the anonymous iSurvey questionnaires:

'Please note: if you are from another profession please use the prototype as an example and answer only one of the questions nine or seven, with your publishers or librarians 'hat' on.'

It may also be necessary to include the same wording in the invitation email that was sent out to the expert participants.

Another limitation of the instrument was a trade off between the granularity of user tasks against the physical and sensory control categories. This was highlighted by one of the experts. Since the automatic BW success criteria that was evaluated in the expert review was for automatic evaluation, the number of criteria was not a problem. However, what needs to be addressed would be a verbosity control on the reports provided by the mobile web accessibility evaluation tool as suggested by Ulltveit-Moe et al. (2008). This may aid stakeholder adoption as commented on by Vigo and Brajnik (2011).

In addition to this, two other key limitations were discovered during this research. Firstly, only one HEI web portal was evaluated; and secondly, a decision had to be made between incorporating a cognitive category verses a cognitive category incorporated within the physical and sensory control categories. The latter was used for this research and substantially increased the complexity of implementation for the researcher. In the future

a separate cognitive control category may be necessary, particularly with the number of potential features that would be required as identified by COGA (2017a).

In terms of accessibility metadata and the accessibility support of API calls across the HEI mobile web etext ecosystem, system and UA permissions on mobile devices could be problematic. Hence, why it was necessary to integrate the instrument and metric into the design and development life cycle of both the automatic evaluation tool, the four web applications for the respective stakeholders and the web service. Updates to accessibility metadata and API calls can be overcome by having a separate repository for API calls and mobile web accessibility guidelines separated from the main evaluation tool and the web service as suggested by Arrue et al. (2007). In addition to this, permissions can be overcome by not needing to automatically evaluate whether an accessibility feature has been required by a user, merely that the availability of the feature can be programmatically determined for the mobile device, ereader application, mobile web browser and the etext formats.

9.4 Concluding remarks about the specification and wireframe

The two main findings of the specification and wireframe were the potential for stakeholder interaction and determining the demand for accessible publications in real time. The stakeholder interaction includes the three way interaction between the academic or student, the HEI librarian, the academic publisher and academic aggregator (see Appendix I).

The specification was written based on the automatic mobile web accessibility automatic BW success criteria that was a direct outcome of the instrument. This was the analysis of user tasks in the HEI etext ecosystem against the accessibility features available on mobile devices, ereader applications, mobile web browsers and etext formats. The accessibility features were categorised under physical and sensory control categories. The main outcome of writing the specification was the development of a proof of concept that enabled the extraction of accessibility metadata from a PDF using a web service.

Producing the wireframe demonstrated how the mobile web accessibility evaluation tool was incorporated into four separate web applications and a web service. It also breaks

down the interactions between the stakeholders from each perspective, and provides where relevant an evaluation report. According to the developer who coded the proof of concept tool it can be setup to allow for the bulk processing of PDFs, for example, but would require hosting either by the HEI using the tool or the academic publisher testing the accessibility of the PDFs they produce in-house.

The wireframe also provides the option to send an inaccessible document to Sensus-Access and for a publisher to show their provision of alt-formats to both the HEI librarian and the academic or student. The combined outcome of both the specification and the wireframe was the realisation that the mobile web accessibility evaluation tool, the four web applications and the web-service could be patented. Since the instrument that this service is based on accommodates print impairments, integrating issues arising for dyslexia it would be a strong competitor to an existing patent (Vitthal and Kumar, 2017) that solely addresses visual impairments.

9.5 Future work

Based on the published research findings referred to in the scope section of this thesis, three potential research contributions for automatic mobile web accessibility evaluation can be made to non HE environments; but that remain within the educational sector, namely:

1. Pre-school to life-long learning by older adults through the use of tablet content;
2. STEM etextbook content that includes multimedia, advanced annotations, complex graphs and schematics (Gylling and Herman, 2014); and finally
3. The use of dedicated devices such as the Kindle Amazon Fire and Nook within the educational sector (Maatta and Laurie, 2014) through the use of a web service.

Neumann argues that preschool digital environments, particularly through the use of tablet devices, encourage children to be actively involved in their learning both through reading, writing and mark making (Neumann, 2016). According to Bläsi and Rothlauf fixed format layouts are also used in children's reading materials and tend to be illustrated (Bläsi and Rothlauf, 2013). The research provided in this thesis has the potential to be repurposed into the preschool digital domain. It can, for example, dovetail with existing

research that assesses the development of fine motor skills by young children when interacting with a touch screen tablet device as referred to by Lin et al. (2017). It would also be useful to assess the extent to which the instrument and metric can determine accessibility support when constrained, for example, by a fixed layout on a tablet screen. This would directly oppose the value of responsive design, unless a means to compartmentalise fixed layout components was made available, allowing a semi responsive design layout. It may also help children with cognitive impairments who may require different or simplified layouts.

According to Sharples life-long learning by older adults is an essential part to continued development outside of the mainstream educational system by promoting the acquisition of new skills (Sharples, 2000). Newell states that peer to peer learning for older adults has also been an effective method to support learning for this peer group, especially when using new technology (Newell, 2011). Older adults, with age related disabilities, may experience combinations of the print impairments referred to in the background chapter of this thesis, such as cognitive and visual impairments. The research presented in this thesis is also therefore relevant to the use of adaptive mobile technology by this demographic as referred to by Sloan et al. (2010) and Gonçalves et al. (2017).

STEM etextbook content that includes multimedia, advanced annotations, complex graphs and schematics (Gylling and Herman, 2014) would also be an area to extend the development of the instrument and metric, particularly in terms of automatic evaluation. This could also include automatically evaluating alt-text for image descriptions through the use of Natural Language Processing (NLP) (Bigham, 2007) and reverse image search (Guinness et al., 2018) within a mobile web accessibility HEI library ecosystem framework.

Dedicated devices such as the Kindle Amazon Fire and Nook are used within the educational sector (Maatta and Laurie, 2014). The use of these devices in the educational sector were beyond the remit of this thesis because there are over 200 devices in the mainstream marketplace. This, however, could be addressed by extending the scope of the mobile web accessibility evaluation tool or suite of tools supported by a web service. Since a web service provides machine to machine communication across a network, this has the potential to allow the evaluation tool to be used by a much wider community of

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design and development teams manufacturing dedicated devices. The use of the instrument and metric could also be extended into the mainstream ebook marketplace, enabling Amazon to assess the accessibility of its own ebookstore on mobile devices. The Amazon ebookstore also provides purchasable academic literature such as Homers the Odyssey.

Another further research area that has already been undertaken involved a regional government website, namely Connect to Support Hampshire (C2SH). With an aging population regional and central governments in the UK are actively investing in the accessibility of their online information outlets on desktop, laptop, tablet and mobile devices. During a three month secondment the researcher advised Hampshire County Council on the accessibility and usability of the C2SH website and mobile application for cognitive impairments in order to meet the accessibility requirements of its core audience, the over 65's. This was achieved by creating a new control category referred to as cognitive functions within the instrument, providing a new set of metrics that could measure the accessibility support for cognitive impairments. This approach was undertaken because of the number of additional accessibility requirements identified for the core demographic as detailed by COGA (2017b). For example, isolated aspects of search features on the C2SH website could be evaluated because the success criteria requires 'hints and tips' to be incorporated in that location on the website to aid those with cognitive impairments. These isolated components could then be assessed holistically against all other components of the website that were tested. The initial testing indicated that further analysis was required.

Appendix A Background search strategy

The following is a summary of the background search strategy. The full set of searches undertaken can be found in: N.E. (2019) Dataset for: Automatically evaluating the mobile web accessibility of Higher Education electronic texts for print impairments. University of Southampton doi: 10.5258/SOTON/D1064 [Dataset] under 'ThesisBackgroundSearches.xlsx'. In total 1,397 papers were identified during the review of the published research findings.

The following logic was used to determine every permutation for the search criteria.

Table A1: Search strategy permutations

	A	B	C	D
A	-	•	•	•
B	•	-	•	•
C	•	•	-	•
D	•	•	•	-

This resulted in the following permutations, see next page.

Table A2: Search strategy outcome

A	Final Strategy removing duplicates:
B	A
C	B
D	C
A+B	D
A+C	A+B
A+D	A+C
B+A	A+D
B+C	B+C
B+D	B+D
C+A	C+D
C+B	A+B+C
C+D	D+A+B
D+A	D+A+C
D+B	D+B+C
D+C	A+B+C+D
A+B+C	Rationalised for use on a spreadsheet:
B+A+C	A
C+A+B	B
D+A+B	C
D+A+C	D
D+B+C	A+B
A+B+C+D	A+C
B+A+C+D	A+D
C+A+B+D	B+C
D+A+B+C	B+D
	C+D
	A+B+C
	A+B+D
	A+C+D
	B+C+D
	A+B+C+D

The duplicates were removed and then rationalised for use on an Excel spreadsheet.

Appendix B Higher Education Statistics (HESA) data sets

The following text was taken from correspondence with HESA when requesting the datasets for 2014/15 to 2017/18.

‘Please note that the figures supplied have been subjected to our standard rounding methodology - see definitions for details.

Data for this enquiry has been extracted from the latest or most appropriate HESA datasets and may differ from HESA data published elsewhere. Please click here for more information about the fixed database.

[We] have provided a link to our standard definitions below. [We] would advise you to take these into account when examining the data.

Student: <https://www.hesa.ac.uk/defs-student>

The information provided within this document is intended for the personal use of the recipient or recipient's organisation only. No information may be passed to third parties or reproduced in the public domain without the express permission of HESA. HESA will hold your contact details to speed up any further enquiries you may have. We won't use your contact details for any other purpose without asking your permission first. HESA cannot accept responsibility for any inferences or conclusions derived from the data by third parties.’

The specified disabilities* in Table, Table, and Table refer to the following:

1. Blind or a serious visual impairment
2. A physical impairment or mobility issues
3. Specific learning difficulty

According to HESA the student data for 2018/19 will be released in January 2020.

B.1 2014/15 HESA Student record data for specified disabilities* and Disabled Student Allowance (DSA) markers

HESA data request 39160

According to the 2014/15 HESA Student Record, the numbers of students with the specified disabilities* at UK HE providers by disability and Disabled Students' Allowance marker were:

Table B1: 2014/15 HESA Student record data for specified disabilities* and Disabled Student Allowance (DSA) markers

2014/15 – request 39160		Disabled students' allowance marker		
Disability	In receipt of Disabled Students' Allowance	Not in receipt of Disabled Students' Allowance	Not known/ Not sought	Total
Blind or a serious visual impairment	1,190	1,840	175	3,205
A physical impairment or mobility issues	3,025	4,570	425	8,020
Specific learning difficulty	61,635	44,835	4165	110,635
Total	65,850	51,250	4765	121,865

Used by permission from the Higher Education Statistics Agency, 2017.

B.2 2015/16 HESA Student record data for specified disabilities* and Disabled Student Allowance (DSA) markers

HESA data request 50998

According to the 2015/16 HESA Student Record, the numbers of students with the specified disabilities* at UK HE providers by disability and Disabled Students' Allowance marker were:

Table B2: 2015/16 HESA Student record data for specified disabilities* and Disabled Student Allowance (DSA) markers.

2015/16 – request 50998		Disabled students' allowance marker		
Disability	In receipt of Disabled Students' Allowance	Not in receipt of Disabled Students' Allowance	Not known/ Not sought	Total
Blind or a serious visual impairment	1,205	1,870	145	3,220
A physical impairment or mobility issues	3,120	4,810	375	8,305
Specific learning difficulty	59,645	49,640	4,120	113,400
Total	63,970	56,320	4,640	124,930

Used by permission from the Higher Education Statistics Agency, 2017.

B.3 2016/17 HESA Student record data for specified disabilities* and Disabled Student Allowance (DSA) markers

HESA data request 55840

According to the 2016/17 HESA Student Record, the numbers of students with the specified disabilities* at UK HE providers by disability and Disabled Students' Allowance marker were:

Table B3: 2016/17 HESA Student record data for specified disabilities* and Disabled Student Allowance (DSA) markers.

2016/17 – request 55840	Disabled students' allowance marker			
Disability	In receipt of Disabled Students' Allowance	Not in receipt of Disabled Students' Allowance	Not known/ Not sought	Total
Blind or a serious visual impairment	1,255	1,975	150	3,380
A physical impairment or mobility issues	3,150	5,240	350	8,740
Specific learning difficulty	56,920	55,060	3,890	115,870
Total	61,320	62,280	4,390	127,990

Used by permission from the Higher Education Statistics Agency, 2018.

B.4 2017/18 HESA Student record data for specified disabilities* and Disabled Student Allowance (DSA) markers

HESA data request 61466

According to the 2017/18 HESA Student Record, the numbers of students with the specified disabilities* at UK HE providers by disability and Disabled Students' Allowance marker were:

Table B4: 2017/18 HESA Student record data for specified disabilities* and Disabled Student Allowance (DSA) markers.

2017/18 – request 61466	Disabled students' allowance marker			
Disability	In receipt of Disabled Students' Allowance	Not in receipt of Disabled Students' Allowance	Not known/ Not sought	Total
Blind or a serious visual impairment	1300	1940	175	3415
A physical impairment or mobility issues	3195	5390	455	9035
Specific learning difficulty	53415	57555	4895	115865
Total	57910	64885	5525	128315

Used by permission from the Higher Education Statistics Agency, 2019.

Appendix C Anonymised coded statements

The following full version of the coded statements were the result of coding in NVIVO. According to NVIVO, the coverage percentage indicates how much of the source content is coded at a specific node. The node is a theme or idea that has been identified.

Table X: The full version of the anonymised coded statements.

Coding	Functional category qualitative statements
FC-NAV	1 reference coded [0.64% Coverage] <i>Reference 1 - 0.64% Coverage</i> Navigating - Finding stuff: Alternative navigation – eg by auto alphabetical list (like in Windows or Android devices) or by user determined categories
FC-TchCntrl	3 references coded [7.42% Coverage] <i>Reference 1 - 3.63% Coverage</i> Alternative options for touch screens for physical difficulties with standard interface. <i>Reference 2 - 2.58% Coverage</i> Touch controls: personalisation of touch functionality (eg easily zoom into target areas for those with poor motor control or tweaking of error sensitivity for trembl[ing] movements) or alternative / bespoke gestures. Options based on touch 'dwell time' so those with 'double click' difficulty can rest the finger on an icon until a menu comes up. Haptic feedback over buttons and control features would support users with poor tactile resolution as well as those with vision or hearing difficulties who would otherwise miss out on audio feedback (eg beeps) or visual cues (eg selected buttons change colour). <i>Reference 3 - 1.22% Coverage</i> touch control

Coding	Functional category qualitative statement
FC-VoiceRecog	2 references coded [6.91% Coverage] <i>Reference 1 - 1.49% Coverage</i> Voice recognition <i>Reference 2 - 5.42% Coverage</i> Navigation options - size of buttons, options to use pointer, voice recognition.
FC-VIEWSCRN	3 references coded [5.01% Coverage] <i>Reference 1 - 2.23% Coverage</i> Ability to customise for a range of visual impairments <i>Reference 2 - 2.70% Coverage</i> Can I alter the look of what I am accessing? <i>Reference 3 - 0.08% Coverage</i> Viewing the screen

Coding	Functional category qualitative statement
FC-ZmRflwRdOrd	9 references coded [16.23% Coverage] <i>Reference 1 - 1.47% Coverage</i> enlargement <i>Reference 2 - 2.11% Coverage</i> ability to enlarge text <i>Reference 3 - 1.09% Coverage</i> text reflow <i>Reference 4 - 1.07% Coverage</i> Viewing the screen - Zoom and reflow: It should be possible to zoom in on the whole screen or alternatively display all menu items (with larger icons and text) in a responsive view where navigation is simpler and no left<>right scrolling is required. <i>Reference 5 - 4.17% Coverage</i> how text is organised (ie. Reflow, page by page, continuous) <i>Reference 6 - 2.33% Coverage</i> Reflow is very important <i>Reference 7 - 2.23% Coverage</i> text flow/reading order <i>Reference 8 - 0.56% Coverage</i> reflow <i>Reference 9 - 1.22% Coverage</i> Magnification

Coding	Functional category qualitative statement
FC-ColrChngs	9 references coded [16.11% Coverage] <i>Reference 1 - 4.78% Coverage</i> text colour + background colour change. <i>Reference 2 - 2.89% Coverage</i> change colours of text/background <i>Reference 3 - 1.00% Coverage</i> font colour <i>Reference 4 - 1.63% Coverage</i> background colour <i>Reference 5 - 0.75% Coverage</i> text colour <i>Reference 6 - 1.15% Coverage</i> background colour <i>Reference 7 - 0.55% Coverage</i> Colour changes: Default background and foreground colours (plus saturation levels) should be capable of being changed by the user. <i>Reference 8 - 1.23% Coverage</i> background colours <i>Reference 9 - 2.13% Coverage</i> text/background colour

Coding	Functional category qualitative statement
FC-FntSize	3 references coded [2.76% Coverage] <i>Reference 1 - 1.54% Coverage</i> Font sizes & type <i>Reference 2 - 0.61% Coverage</i> Text size <i>Reference 3 - 0.61% Coverage</i> Font size
FC-ImgTxt	1 reference coded [1.91% Coverage] <i>Reference 1 - 1.91% Coverage</i> remove images for plain text
FC-ColCntrst	1 reference coded [1.40% Coverage] <i>Reference 1 - 1.40% Coverage</i> Colour contrast
FC-AUD-ALTACCESS	1 reference coded [0.19% Coverage] <i>Reference 1 - 0.19% Coverage</i> Audio and alternatives - Alternative access:

Coding	Functional category qualitative statement
FC-VoiceFdbckTTS	7 references coded [9.21% Coverage] <i>Reference 1 - 1.72% Coverage</i> Text to speech <i>Reference 2 - 1.23% Coverage</i> Text-to-speech <i>Reference 3 - 1.36% Coverage</i> text to speech <i>Reference 4 - 0.62% Coverage</i> speech settings <i>Reference 5 - 2.01% Coverage</i> Voice feedback on all navigational elements and text to speech on all textual elements. Although the two will need to be linked for some users it is important to allow easily accessed text to speech on all text displays. Text to speech should allow easy alternatives such as read word, paragraph, page, document and be intelligent enough to recognise body text and isolate it from other text artefacts like headers and footers etc – it should be sensitive to reading order. <i>Reference 6 - 0.97% Coverage</i> read aloud <i>Reference 7 - 1.31% Coverage</i> text to speech

Coding	Functional category qualitative statement
FC-HI	3 references coded [5.04% Coverage] <i>Reference 1 - 1.77% Coverage</i> Vibrate settings for hearing impairments. <i>Reference 2 - 1.98% Coverage</i> Can I hear what I am accessing? <i>Reference 3 - 1.29% Coverage</i> Hearing: audio options should include mixing desk style sliders so those people needing to boost certain audio ranges can do so easily and independently. Integration of real time audio amplification and relay via inbuilt microphone and mixing sliders would allow devices to act as discrete hearing aids.
FC-Smplifi	1 reference coded [2.16% Coverage] <i>Reference 1 - 2.16% Coverage</i> Can I simplify what I am accessing?
FC-RdAlong	1 reference coded [1.56% Coverage] <i>Reference 1 - 1.56% Coverage</i> Can I see what is playing?

Coding	Category principles qualitative statements
CP-LBLDIS	1 reference coded [3.83% Coverage] <i>Reference 1 - 3.83% Coverage</i> Principles should be driven by how the user thinks about their access needs. Some will think about it in terms of the label of their disability. Teachers and professionals supporting users are likely to focus on the label of the disability.
CP-INCL	2 references coded [9.46% Coverage] <i>Reference 1 - 8.33% Coverage</i> I am not sure I fully understand this question - but the principles should be fairness, equality and accessibility. <i>Reference 2 - 1.13% Coverage</i> Inclusiveness
CP-IMPROV-FUNC	1 reference coded [1.97% Coverage] <i>Reference 1 - 1.97% Coverage</i> Principles should be driven by how the user thinks about their access needs. [...] while some will think about the functionality they are trying to improve.
CP-PrcssFlex	1 reference coded [4.11% Coverage] <i>Reference 1 - 4.11% Coverage</i> That all digital documents should be processed flexibly for the end user.
CP-Adaptive	1 reference coded [7.03% Coverage] <i>Reference 1 - 7.03% Coverage</i> Personalisation and efficiency options – ie human centred and use centred design.

Coding	Category principles qualitative statements
CP-Adaptable	3 references coded [24.99% Coverage] <i>Reference 1 - 8.33% Coverage</i> Is it adaptable to need? <i>Reference 2 - 8.33% Coverage</i> Should aim to make device easily configured to meet the needs of individual users. <i>Reference 3 – 8.33% Coverage</i> Tree logic based on the function of the categories eg. display customisation, audio settings etc.
CP-LvlAccssRestrict	4 references coded [29.22% Coverage] <i>Reference 1 - 8.33% Coverage</i> To enable all users to have equal levels of access to the functions of the device. <i>Reference 2 - 8.33% Coverage</i> Choice, Equity of Access <i>Reference 3 - 4.22% Coverage</i> That publishers should not restrict the functional categories for any users. <i>Reference 4 - 8.33% Coverage</i> Tree logic based on the function of the categories eg. display customisation, audio settings etc.
CP-ExpCtrlOutcome	2 references coded [16.67% Coverage] <i>Reference 1 - 8.33% Coverage</i> Can a user navigate the content on audio cues? Are shortcuts available for those with dexterity issues? <i>Reference 2 - 8.33% Coverage</i> Generic across platforms. Similar functionality (should respond in the same way). Expected controls and outcomes.

Appendix D Detailed device and mobile browser API accessibility support

The following is a summarised version of the full dataset that can be found in: N.E. (2019) Dataset for: Automatically evaluating the mobile web accessibility of Higher Education electronic texts for print impairments.

University of Southampton doi: 10.5258/SOTON/D1064 [Dataset] under 'INSTRUMENTEcontentSubsumedFINAL2019.xlsx'. Please select the second tab Search 2.

The expected outcomes are mapped to WCAG 2.0, EN 301549 and ETSI EG 203 350. This is indicated below unless otherwise stated.

Search 2	Accessibility support outcome								
Can the following device and mobile browser features be detected programmatically?	Device			Android Mobile Browser					Exposed API accessibility metadata by mobile browser
	iOS	Android	Windows	Chrome	Firefox	Safari	Opera	Explorer	
1 Visual Controls - Themes & Styles: High Contrast. Technically the Windows phone is providing actual High Contrast rather than colour inversion that iOS and Android provide).	✓	✓	✓	✗	✗	-	✗	-	Expected Outcome: WCAG 2.0: SC 1.4.3 (AA), SC 1.4.6 (AAA), SC 1.4.8 (AAA); UAAG 2.0: 1.1.1., SC 1.1.3, SC 2.6.4, SC 3.2.2, SC 5.1.3 Expected outcomes – see spreadsheet.

Search 2	Accessibility support outcome									
Can the following device and mobile browser features be detected programmatically?	Device			Android Mobile Browser					Exposed API accessibility metadata by OS	Exposed API accessibility metadata by mobile browser
	iOS	Android	Windows	Chrome	Firefox	Safari	Opera	Explorer		
1 Visual Controls - Themes & Styles: Brightness	✓	✓	✗	✗	✓	-	✗	-	iOS brightness (https://goo.gl/A8Z29X) Android FeatureInfo (https://goo.gl/WFTLCj); SCREEN_BRIGHTNESS (https://goo.gl/quLmVi) Windows GetLevelForScenario(DisplayBrightnessScenario) Pre Release (https://goo.gl/Fy5fz6) Expected outcomes – see spreadsheet.	Firefox for Android: DeviceLightEvent (https://goo.gl/A5VM8B) Experimental Expected Outcome: WCAG 2.0: SC 1.4.3.; UAAG 2.0: SC 1.4.5, SC 2.10.8.

Appendix D: Detailed device and mobile browser API accessibility support

Search 2	Accessibility support outcome									
Can the following device and mobile browser features be detected programmatically?	Device			Android Mobile Browser					Exposed API accessibility metadata by OS	Exposed API accessibility metadata by mobile browser
	iOS	Android	Windows	Chrome	Firefox	Safari	Opera	Explorer		
1 Visual Controls - Themes & Styles: Text Colour	✓	✓	✓	✓	✓	-	✓	-	iOS textColor (https://goo.gl/pNQJmd) Android FeatureInfo (https://goo.gl/WFTLCj); android:textAppearance (https://goo.gl/w7k2lk) android:textColor (https://goo.gl/x6l1mx) Windows Foreground (https://goo.gl/tncJ4E) Expected Outcome: EN 301549: SC 4.2.2, SC 4.2.3, SC 4.2.10, SC 8.1.3, 10.2.12, SC 11.2.1.12, SC 11.3.2.10, SC 11.5; ETSI EG 203 350: SC 7.8.5; WCAG 2.0: SC 1.4.1, SC 1.4.3;	Chrome for Android; Firefox for Android; Opera Mini: supported by CSS1 color (https://goo.gl/tm4c31) Expected Outcome: WCAG 2.0: SC 1.4.1, SC 1.4.3; UAAG 2.0: SC 1.4.1, SC 1.4.2, SC 1.4.5, SC 1.7.1, SC 1.7.2, SC 1.7.3, SC 2.7.1.

Search 2	Accessibility support outcome									
Can the following device and mobile browser features be detected programmatically?	Device			Android Mobile Browser					Exposed API accessibility metadata by OS	Exposed API accessibility metadata by mobile browser
	iOS	Android	Windows	Chrome	Firefox	Safari	Opera	Explorer		
1 Visual Controls - Themes & Styles: Background Colour	✓	✓	✓	✓	✓	-	✓	-	iOS background-color (https://goo.gl/wlobqn); UIView (https://goo.gl/ClfK5s) Android FeatureInfo (https://goo.gl/WFTLCj); getBackgroundColor (https://goo.gl/3LmSF8) Windows BrandedPageBackgroundBrush (https://goo.gl/c0NlzK) Expected Outcome: EN 301 549: SC 4.2.2, SC 4.2.3, 4.2.10, SC 8.1.3, SC 11.5; ETSI EG 203 350: SC 7.8.5 WCAG 2.0: SC 1.4.1, SC 1.4.3; SC 1.4.6, SC 1.4.8	Chrome for Android; Firefox for Android; Opera Mini: supported by CSS1 background-color (https://goo.gl/Zdg5QH) Expected Outcome: WCAG 2.0: SC 1.4.1, SC 1.4.3; SC 1.4.6, SC 1.4.8; WCAG 2.0; UAAG 2.0: Please see spreadsheet.

Appendix D: Detailed device and mobile browser API accessibility support

Search 2	Accessibility support outcome									
Can the following device and mobile browser features be detected programmatically?	Device			Android Mobile Browser					Exposed API accessibility metadata by OS	Exposed API accessibility metadata by mobile browser
	iOS	Android	Windows	Chrome	Firefox	Safari	Opera	Explorer		
1 Visual Controls - Themes & Styles: Colour Correction/Filter	?	?	✓	?	?	-	?	?	iOS UIColor (https://goo.gl/eUhwod); CGColor (https://goo.gl/nMd3uL) Does not explicitly refer to iOS 10 Color Filter although feature available to the user. Android FeatureInfo (https://goo.gl/WFTLCj); Color (https://goo.gl/NsJWaL) Does not explicitly specify the accessibility feature colour correction although it is available to the user. Windows Color combinations (https://goo.gl/ouMu8E) Expected Outcome: Please see spreadsheet.	Expected outcomes: WCAG 2.0: SC 1.3.3, SC 1.4.1; UAAG 2.0: SC 1.1.2, SC 1.3.1, SC 1.7.1, SC 1.7.2, SC 1.7.3, SC 4.1.2, SC 5.1.3

Search 2	Accessibility support outcome									
Can the following device and mobile browser features be detected programmatically?	Device			Android Mobile Browser					Exposed API accessibility metadata by OS	Exposed API accessibility metadata by mobile browser
	iOS	Android	Windows	Chrome	Firefox	Safari	Opera	Explorer		
1 Visual Controls - Themes & Styles: Pre-set Text Colour & Background Colour	?	?	✓	?	?	-	?	-	iOS theme (https://goo.gl/iUPmit) This does not explicitly refer to pre-set text & background colour. Android FeatureInfo (https://goo.gl/WFTLCj); Resources.Theme (https://goo.gl/axc6BH) Does not explicitly specify pre-set text and background colour attributes. Windows ThemeResource markup extension (https://goo.gl/) Please see spreadsheet for expected outcomes. Important: WCAG 2.0 does not explicitly refer to themes.	WCAG 2.0: SC 1.4.1, SC 1.4.3, SC 1.4.6, SC 1.4.8; UAAG 2.0: SC 1.1.3, SC 1.3.2, SC 1.3.3, SC 1.3.4, SC 1.3.5 SC 1.4.1, SC 1.4.2, SC 1.4.5, SC 1.7.1, SC 1.7.2, SC 1.7.3, SC 1.8.1, SC 1.8.7, SC 2.7.1, SC 4.1.2.

Search 2	Accessibility support outcome								
Can the following device and mobile browser features be detected programmatically?	Device			Android Mobile Browser					Exposed API accessibility metadata by mobile browser
	iOS	Android	Windows	Chrome	Firefox	Safari	Opera	Explorer	
1 Visual Controls - Themes & Styles: Font Family/Typeface	✓	✓	✓	✓	✓	-	✓	-	iOS UIFontDescriptor (https://goo.gl/5QTOLW); familyNames (https://goo.gl/Y9xNr6) Android FeatureInfo (https://goo.gl/WFTLCj); android:textAppearance (https://goo.gl/w7k2lk) android:typeface (https://goo.gl/Cdf7Nx) Windows FontFamily (https://goo.gl/bkqYTb) Expected Outcome: EN 301 549 SC 11.5; ETSI EG 203 350: SC 7.8.2; WCAG 2.0: SC 1.4.4, SC 1.4.5, SC 1.4.8, SC 1.4.9. Important: WCAG 2.0 does not explicitly refer to font family.

Search 2	Accessibility support outcome									
Can the following device and mobile browser features be detected programmatically?	Device			Android Mobile Browser					Exposed API accessibility metadata by OS	Exposed API accessibility metadata by mobile browser
	iOS	Android	Windows	Chrome	Firefox	Safari	Opera	Explorer		
1 Visual Controls – Layout (white space) and declutter: Margin Spacing	✓	✓	✓	✓	✓	-	✓	-	iOS layoutMargins (https://goo.gl/u2iOUX) Android FeatureInfo (https://goo.gl/WFTLCj); getMarginStart (https://goo.gl/LujV5c); getMarginEnd (https://goo.gl/8L3GoX) Windows Margin (https://goo.gl/kjcoCE) Expected Outcome: EN 301 549: SC 4.2.10 Important: Does not explicitly refer to Margin Spacing; WCAG 2.0: SC 1.4.8.	Chrome for Android; Firefox for Android; Opera Mini: CSS 1 margin (https://goo.gl/EZZNGY) Expected Outcome: WCAG 2.0: SC 1.4.8. UAAG 2.0: SC 1.4, SC 1.4.2, SC 1.4.3, SC 1.4.4.

Appendix D: Detailed device and mobile browser API accessibility support

Search 2	Accessibility support outcome									
Can the following device and mobile browser features be detected programmatically?	Device			Android Mobile Browser					Exposed API accessibility metadata by OS	Exposed API accessibility metadata by mobile browser
	iOS	Android	Windows	Chrome	Firefox	Safari	Opera	Explorer		
1 Visual Controls - Layout (white space) and declutter: Line spacing	✓	✓	✓	✓	✓	-	✓	-	iOS lineSpacing (https://goo.gl/NllyJZ); leading (https://goo.gl/CGfv2l) Android FeatureInfo (https://goo.gl/WFTLCj); android:lineSpacingExtra (https://goo.gl/bCnLgx) Windows LineSpacingRule Enum (https://goo.gl/4Be0t1); LineHeight (https://goo.gl/3sDwPT) Expected Outcome: Important: EN 301 549: SC 4.2.10 Important: Does not explicitly refer to Line Spacing; ETSI EG 203 350: SC 7.8.6; WCAG 2.0: SC 1.4.8.	Chrome for Android; Firefox for Android; Opera Mini: CSS1 line-height (https://goo.gl/7l4vR5); Expected Outcome: WCAG 2.0: SC 1.4.8. UAAG 2.0: SC 1.4, SC 1.4.1, SC 1.4.2, SC 1.4.3.

Search 2	Accessibility support outcome									
Can the following device and mobile browser features be detected programmatically?	Device			Android Mobile Browser					Exposed API accessibility metadata by OS	Exposed API accessibility metadata by mobile browser
	iOS	Android	Windows	Chrome	Firefox	Safari	Opera	Explorer		
1 Visual Controls – Layout (white space) and declutter: Character/Letter Spacing	✓	✓	✓	✓	✓	-	✓	-	iOS NSKernAttributeName (https://goo.gl/6VeZ24); UILabel (https://goo.gl/6kulcu) Android FeatureInfo (https://goo.gl/WFTLCj); android:letterSpacing (https://goo.gl/qsLM12) Windows CharacterSpacing (https://goo.gl/qMhJGD) Expected Outcome: EN 301 549: SC 4.2.10 Important: Does not explicitly refer to Character Spacing; WCAG 2.0: SC 1.4.8. Important: This SC does not explicitly refer to character spacing.	Chrome for Android; Firefox for Android; Opera Mini: CSS1 letter-spacing (https://goo.gl/nwnDw3) Expected Outcome: WCAG 2.0: SC 1.4.8. Important: This SC does not explicitly refer to character spacing. UAAG 2.0: SC 1.4, SC 1.4.3.

Appendix D: Detailed device and mobile browser API accessibility support

Search 2	Accessibility support outcome								
Can the following device and mobile browser features be detected programmatically?	Device			Android Mobile Browser					Exposed API accessibility metadata by mobile browser
	iOS	Android	Windows	Chrome	Firefox	Safari	Opera	Explorer	
1 Visual Controls - Layout (white space) and declutter: Left Justification (Ragged Right)	✓	✓	✓	✓	✓	-	✓	-	iOS textAlignment (https://goo.gl/JEmWTB); UILabel (https://goo.gl/6kulcu) Android FeatureInfo (https://goo.gl/WFTLCj); getJustify (https://goo.gl/dkQdmz) Windows TextAlignment Enum (https://goo.gl/KOVrb0) Expected Outcome: EN 302 549: SC 4.2.10 Important: Does not explicitly refer to Ragged Right Justification; WCAG 2.0: SC 1.4.8.

Search 2	Accessibility support outcome									
Can the following device and mobile browser features be detected programmatically?	Device			Android Mobile Browser					Exposed API accessibility metadata by OS	Exposed API accessibility metadata by mobile browser
	iOS	Android	Windows	Chrome	Firefox	Safari	Opera	Explorer		
1 Visual Controls – Layout (white space) and declutter: Full screen	✓	✓	✓	✓	✓	-	✖	-	iOS fullScreen (https://goo.gl/y2uRmO) Android FeatureInfo (https://goo.gl/WFTLCj); SYSTEM_UI_FLAG_FULLSCREEN (https://goo.gl/CbRM50) Windows IsFullScreenMode (https://goo.gl/kJoUH3) Expected Outcome: EN 301 549: SC 4.2.10, SC 11.3.2.10; ETSI EG 203 350: SC 12.5.6; WCAG 2.0: SC 1.3.1, SC 3.3.2.	Chrome for Android; Firefox for Android: element.requestFullscreen() (https://goo.gl/ukgDgJ) Opera for Android: Full screen (hide toolbar) is a feature available to the user. API unsupported (http://caniuse.com/#search=fullscreen). Expected outcome see spreadsheet.

Search 2	Accessibility support outcome									
Can the following device and mobile browser features be detected programmatically?	Device			Android Mobile Browser					Exposed API accessibility metadata by OS	Exposed API accessibility metadata by mobile browser
	iOS	Android	Windows	Chrome	Firefox	Safari	Opera	Explorer		
1 Visual Controls – Resizing: Text/font size	✓	✓	✓	✓	✓	-	✓	-	iOS <code>pointSize</code> (https://goo.gl/d0xwRv) Android <code>FeatureInfo</code> (https://goo.gl/WFTLCj); <code>android:textSize</code> (https://goo.gl/kLh4vi) Windows <code>TextScaleFactor</code> (https://goo.gl/ZU9O7A); <code>IsTextScaleFactorEnabled</code> (https://goo.gl/goXPB1); <code>FontSize</code> (https://goo.gl/ImnGTf) Expected Outcome: EN 301 549: SC 4.2.2, SC 11.5; ETSI EG 203 350: SC 7.8.1; WCAG 2.0: SC 1.4.4 (AA)	Chrome for Android: CSS 1 font-size (https://goo.gl/wkN8mA) Text scaling (incl. reflow) user feature. Firefox for Android: CSS 1 font-size (https://goo.gl/wkN8mA) Text size user feature. Opera for Android: CSS 1 font-size (https://goo.gl/wkN8mA). Expected outcome: see spreadsheet.

Search 2	Accessibility support outcome									
Can the following device and mobile browser features be detected programmatically?	Device			Android Mobile Browser					Exposed API accessibility metadata by OS	Exposed API accessibility metadata by mobile browser
	iOS	Android	Windows	Chrome	Firefox	Safari	Opera	Explorer		
1 Visual Controls – Resizing: Zoom/ Magnification	✓	✓	✓	✓	✓	-	✗	-	iOS UIScrollView (https://goo.gl/TN01Du); UIAccessibilityZoomFocusChanged (https://goo.gl/JUuxOt); UIAccessibilityZoomType (https://goo.gl/W8TaLI) Android FeatureInfo (https://goo.gl/WFTLCj); ZoomControls (https://goo.gl/cj5GJ3) ZoomControl Class (https://goo.gl/J9OYfQ) Expected Outcome: EN 301 549: SC 4.2.2; WCAG 2.0: SC 1.4.4 (AA) Please also see expected outcome on spreadsheet for mobile browsers.	Chrome for Android: http://caniuse.com/#search=zoom Force enable zoom. CSS3 transform (https://goo.gl/QeXpyo) Firefox for Android: Always enable zoom. CSS3 transform. Opera for Android: Force enable zoom CSS3 transform (https://goo.gl/QeXpyo)

Search 2	Accessibility support outcome									
Can the following device and mobile browser features be detected programmatically?	Device			Android Mobile Browser					Exposed API accessibility metadata by OS	Exposed API accessibility metadata by mobile browser
	iOS	Android	Windows	Chrome	Firefox	Safari	Opera	Explorer		
1 Visual Controls – Resizing: Reflow/Text or Word Wrap/Overflow Wrap/Thrashing	✓	✓	✗	✓	✓	-	✓	-	iOS UIViewContentMode (https://goo.gl/2lzuCM) Android FeatureInfo (https://goo.gl/WFTLCj); setPaintFlags (https://goo.gl/tkwhBG) Windows Not Supported Expected Outcome: EN 301 549: SC 4.2.2, SC 4.2.10; WCAG 2.0: SC 1.4.8	Chrome for Android: CSS3: word-wrap (https://goo.gl/Og5FCA) Text scaling (incl. reflow) user feature. Firefox for Android: CSS3: word-wrap (https://goo.gl/Og5FCA) Opera for Android: CSS3: word-wrap (https://goo.gl/Og5FCA) Expected outcome: see spreadsheet.

Search 2	Accessibility support outcome									
Can the following device and mobile browser features be detected programmatically?	Device			Android Mobile Browser					Exposed API accessibility metadata by OS	Exposed API accessibility metadata by mobile browser
	iOS	Android	Windows	Chrome	Firefox	Safari	Opera	Explorer		
2 Touch Controls – Device Gestures (the underlying technology is whether focus can be altered – this is true for gestures, navigating while using a screen reader and the use of switch access control).	✓	✓	✓	✓	✓	-	✓	-	iOS UIGestureRecognizer (https://goo.gl/Cujlr7); UIAccessibilityFocusedElement (https://goo.gl/El92Bm) Android FeatureInfo (https://goo.gl/WFTLCj); getGestureEntries (https://goo.gl/hQowi1) Windows GestureRecognizer Class (https://goo.gl/ioXEpQ); GestureSettings Enum (https://goo.gl/5wZziV) Expected outcome see spreadsheet.	Chrome for Android: Supported (https://goo.gl/A2FzJq); Firefox for Android: Supported (https://goo.gl/A2FzJq); Opera Mini: Supported (https://goo.gl/A2FzJq) Gestures integral to moving Focus :focus (https://goo.gl/lUrZ88) Expected outcomes see spreadsheet.

Appendix D: Detailed device and mobile browser API accessibility support

Search 2	Accessibility support outcome									
Can the following device and mobile browser features be detected programmatically?	Device			Android Mobile Browser					Exposed API accessibility metadata by OS	Exposed API accessibility metadata by mobile browser
	iOS	Android	Windows	Chrome	Firefox	Safari	Opera	Explorer		
2 Touch Controls – Hard Volume Button (Page Turn)	✓	✓	✗	✗	✗	-	✗	-	iOS NSNotification (https://goo.gl/xcMUNL) Android FeatureInfo (https://goo.gl/WFTLCj); registerMediaButtonEventListenerReceiver (https://goo.gl/dys3xc), this requires use of OnBind (https://goo.gl/QHD5YJ) Windows Not Supported Expected Outcome: EN 301 549: SC 4.2.1, SC 5.1.6.1; WCAG 2.0: SC 2.1.1	Expected Outcome: WCAG 2.0: SC 2.1.1. UAAG 2.0: SC 2.3.5.

Search 2	Accessibility support outcome									
Can the following device and mobile browser features be detected programmatically?	Device			Android Mobile Browser					Exposed API accessibility metadata by OS	Exposed API accessibility metadata by mobile browser
	iOS	Android	Windows	Chrome	Firefox	Safari	Opera	Explorer		
2 Touch Controls – Screen orientation	✓	✓	✓	✓	✓	-	✗	-	iOS UIWindow https://goo.gl/PjgBie Android FeatureInfo https://goo.gl/WFTLCj ; screenOrientation https://goo.gl/vlVVft Windows SimpleOrientation Enum https://goo.gl/tKuENR ; Orientation https://goo.gl/MQqRxm Expected Outcome: EN 301 549: SC 4.2.8; WCAG 2.0 Mobile: 4.1 (https://goo.gl/9HgpuW)	Chrome for Android: Supported http://caniuse.com/#search=screen Screen.orientation; Firefox for Android: Screen.orientation Experimental https://goo.gl/VrxVQj Expected Outcome: WCAG 2.0 Mobile: 4.1 (https://goo.gl/9HgpuW)

Appendix D: Detailed device and mobile browser API accessibility support

Search 2	Accessibility support outcome									
Can the following device and mobile browser features be detected programmatically?	Device			Android Mobile Browser					Exposed API accessibility metadata by OS	Exposed API accessibility metadata by mobile browser
	iOS	Android	Windows	Chrome	Firefox	Safari	Opera	Explorer		
3 Audible Controls – Screen reader	✓	✓	✗	✓	✓	-	✓	-	iOS UIAccessibilityIsSpeakScreenEnabled (https://goo.gl/susnQ3) Android FeatureInfo (https://goo.gl/WFTLCj); isEnabled (https://goo.gl/Lrc0Fe) Windows Not Supported Expected Outcome: EN 301 549: SC 4.2.1, SC 4.2.2, SC 5.1.3.1, SC 5.1.3.2, SC 5.1.3.4, SC 11.2.1.1, SC 11.2.2.8; WCAG 2.0: SC 1.3.1, SC 1.3.2, SC 2.4.7 Please see the spreadsheet for the mobile browser expected outcomes.	Chrome for Android: Supported (https://goo.gl/BptR1z) enables navigation through HTML5 & ARIA labels, headings, landmarks, links and controls. Firefox for Android: Supported (as above). Opera Mini for Android: Supported (as above)

Search 2	Accessibility support outcome									
Can the following device and mobile browser features be detected programmatically?	Device			Android Mobile Browser					Exposed API accessibility metadata by OS	Exposed API accessibility metadata by mobile browser
	iOS	Android	Windows	Chrome	Firefox	Safari	Opera	Explorer		
3 Audible Controls – Text to Speech (TTS)	✓	✓	✓	✗	✗	-	✗	-	iOS AVSpeechSynthesizer (https://goo.gl/fLZR7e) Android FeatureInfo (https://goo.gl/WFTLCj); android.speech.tts (https://goo.gl/ddsoEV) Windows Windows.Media.SpeechSynthesis Namespace (https://goo.gl/aWZJnM) Expected Outcome: EN 301 549: SC 4.2.2, SC 4.2.10, SC 5.1.3.2, SC 5.1.3.4, SC 5.1.3.14, SC 8.5; ETSI EG 203 350: SC 12.5.14; WCAG 2.0: SC 1.3.1, SC 3.1.1	Chrome for Android: Not supported, but Chrome OS (Desktop) does support chrome.tts (https://goo.gl/DvibHK), but no user feature is available in the browser. Firefox for Android: Web Speech API (https://goo.gl/J4sypA) Pending. Expected outcome please see spreadsheet.

Appendix D: Detailed device and mobile browser API accessibility support

Search 2	Accessibility support outcome									
Can the following device and mobile browser features be detected programmatically?	Device			Android Mobile Browser					Exposed API accessibility metadata by OS	Exposed API accessibility metadata by mobile browser
	iOS	Android	Windows	Chrome	Firefox	Safari	Opera	Explorer		
3 Audible Controls Simplification – Read along	x	?	x	x	x	-	x	-	iOS Not Supported Android FeatureInfo (https://goo.gl/WFTLCj); android:textColorHighlight (https://goo.gl/4f2mQx) This does not explicitly refer to read along. Windows Not Supported Expected Outcome: EN 301 549: SC 4.2.2, SC 4.2.10; WCAG 2.0: SC 1.3.1, SC 1.4.1, SC 3.1.1, SC 3.1.5	Expected Outcome: WCAG 2.0: SC 1.3.1, SC 1.4.1, SC 3.1.1, SC 3.1.5. UAAG 2.0: 1.6, SC 1.6.1, SC 1.6.2, SC 1.6.3, SC 1.6.4, SC 1.6.5. Epub3 accessibility guidelines provide CSS media overlays (https://goo.gl/dlyW4y) specifically for this purpose.

Search 2	Accessibility support outcome									
Can the following device and mobile browser features be detected programmatically?	Device			Android Mobile Browser					Exposed API accessibility metadata by OS	Exposed API accessibility metadata by mobile browser
	iOS	Android	Windows	Chrome	Firefox	Safari	Opera	Explorer		
3 Audible Controls Simplification – Complex to Simple Words	?	x	x	x	x	-	x	-	iOS NSLinguisticTagger (https://goo.gl/Cmmqtj) Automatically segments natural-language text and tags it with information. This does not explicitly refer to complex to simple words. Android Not Supported Windows Not Supported Expected Outcome: EN 301 549: SC 4.2.10; ETSI EG 203 350: SC 7.1, SC 7.3, SC 7.4, SC 7.5, SC 7.6, SC 7.8; WCAG 2.0: SC 3.1.3, SC 3.1.4, SC 3.1.5	Expected Outcome: WCAG 2.0: SC 3.1.3, SC 3.1.4, SC 3.1.5. UAAG 2.0: SC 1.9.1, SC 2.7.1.

Appendix D: Detailed device and mobile browser API accessibility support

Search 2	Accessibility support outcome									
Can the following device and mobile browser features be detected programmatically?	Device			Android Mobile Browser					Exposed API accessibility metadata by OS	Exposed API accessibility metadata by mobile browser
	iOS	Android	Windows	Chrome	Firefox	Safari	Opera	Explorer		
4 Voice Controls Voice Recognition	✓	✓	✓	✓	✗	-	✗	-	iOS Speech (https://goo.gl/1JphMU) Android FeatureInfo (https://goo.gl/WFTLCj); isRecognitionAvailable (https://goo.gl/oXEuLM) Windows Windows.Phone.Speech. Recognition Namespace (https://goo.gl/g7IZCi) Expected Outcome: EN 301 549: SC 4.2.1, SC 4.2.2, SC 4.2.7, SC 4.2.8, SC 4.2.10; ETSI EG 203 350: SC 12.6.11; WCAG 2.0: SC 4.1.2. Please see the spreadsheet for the mobile browser expected outcomes.	Chrome for Android: Speech Recognition API - partial support (http://caniuse.com/#feat=speech-recognition) Firefox for Android: Web Speech API (https://goo.gl/J4sypA) Pending Voice input (allow voice dictation in the URL bar) is a feature available to the user.

Appendix E Detailed mapped core device accessibility settings

The full dataset for the detailed mapped core device accessibility settings can be found in: N.E. (2019) Dataset for: Automatically evaluating the mobile web accessibility of Higher Education electronic texts for print impairments. University of Southampton doi: 10.5258/SOTON/D1064 [Dataset] under 'CoreMappedAccessibilitySettings.xlsx'. This is also supported by 'ReducingFeatures2CoreAccessibilitySettings.xlsx' under the same DOI.

Manufacturers of mobile devices may examine the settings of their competitor's platforms. The following list of settings is not exhaustive. The aim was to capture as many that could be mapped across the maximum number of devices. It is not to say that there are settings, such as Ignore Repeat for switch access control, that should be included but only the iPhone had this setting available. Another setting in this category is Highlight Content (overlay - media query), available for iOS 9.1. On the Nexus 5, there is a setting for managing custom labels for images. There is no equivalent in iOS 9.1. Having said that there is reference to button 'labels' under accessibility. Also in the context menu/rotor menus the Android has the setting to read at paragraph level and the iPhone does not. The iPhone has the option to read at heading level and the Android phone does not.

Appendix E: Detailed mapped core device accessibility settings

Table E1: Mapped core device HE and accessibility settings.

No.	Android Nexus 5	iPhone 6	Windows Phone 8.1	Framework	Input Output	Relevance to HEI ereading
1	Wi-Fi	Wi-Fi	WiFi	Discovery	Input and output	Required to access HEI library portal via Eduroam on campus.
2	VPN	VPN	VPN	Discovery	Input and output	Required to access HEI library portal via 4G off campus.
3	Bluetooth	Bluetooth	Bluetooth	Device	Input and output if refreshable Braille display is used.	Required to access Bluetooth keyboard and Braille devices.

Appendix E: Detailed mapped core device accessibility settings

No.	Android Nexus 5	iPhone 6	Windows Phone 8.1	Framework	Input Output	Relevance to HEI ereading
4	Brightness Level Slider	Brightness Slider	x3 Brightness Sliders	Device and ereader (potential conflict). Viewing screen.	Input and output	Required to view screen in bright sunlight or to reduce screen glare when reading at night.
5	Adaptive Brightness On/Off	Auto- Brightness On/Off	Automatically Adjust	Device. Viewing screen.	Output	Required to view screen in bright sunlight or to reduce screen glare when reading at night.
6	Magnification Gestures	Display Zoom	Screen Magnifier	Device and ereader (potential conflict). Viewing screen.	Input and output	Required when viewing a PDF that does not allow reflow or a website that does not allow text size or image size alterations. This can cause horizontal scrolling.

Appendix E: Detailed mapped core device accessibility settings

No.	Android Nexus 5	iPhone 6	Windows Phone 8.1	Framework	Input Output	Relevance to HEI ereading
7	Font Size	Text Size	Text Size	Device and ereader (potential conflict). Viewing screen.	Input and output	Required to help visually impaired readers to customise etext size when reading.
8	Large Text	Larger Text	Menu text size large by default.	Device and ereader (potential conflict). Viewing screen.	Input and output	Required to help visually impaired users to read OS setting menus.
9	Storage and USB	Storage and iCloud Usage	Storage Sense and USB	Econtent format download	Input and output	Management of device storage and cloud storage is required for etexts.

Appendix E: Detailed mapped core device accessibility settings

No.	Android Nexus 5	iPhone 6	Windows Phone 8.1	Framework	Input Output	Relevance to HEI ereading
10	Google Search	Siri	Cortana	Discovery	Input and output	Voice Recognition aids searching and the reading of etexts but is not recommended for large amounts of text because of battery consumption.

Appendix E: Detailed mapped core device accessibility settings

11	Language and input	Language and Region	Language and Region	Device and ereader (potential conflict).	Input and output	Required so the user can set the language of their preference and to then display on screen text in that chosen language.

Appendix E: Detailed mapped core device accessibility settings

No.	Android Nexus 5	iPhone 6	Windows Phone 8.1	Framework	Input Output	Relevance to HEI ereading
12	Talkback On/Off	VoiceOver On/Off	Narrator On/Off	Device. Audio.	Input and output	Required specifically for the user to navigate from the OS to the ereader. Potential conflict between the OS and the UA if TTS is allowed to operate at the same time the OS screen reader is allowed to read aloud.
13	Speech Rate	Speaking Rate - Slider	Speed	Device and ereader (potential conflict). Audio.	Input and output	This would be required in both the OS and the UA menu settings and when reading the econtent.

Appendix E: Detailed mapped core device accessibility settings

No.	Android Nexus 5	iPhone 6	Windows Phone 8.1	Framework	Input Output	Relevance to HEI ereading
14	Speak usage hints	Speak Hints On/Off	Read hints for controls and buttons	Device and ereader (potential conflict). Audio.	Output	This is required for inexperienced users requiring further assistance for accessibility when in the OS and the UA.
15	Use pitch changes	Use Pitch Change	Not available	Device and ereader (potential conflict). Audio.	Output	This changes the pitch of the screen reader's voice when echoing the key typed on the keyboard. Required for annotations in etexts.

Appendix E: Detailed mapped core device accessibility settings

No.	Android Nexus 5	iPhone 6	Windows Phone 8.1	Framework	Input Output	Relevance to HEI ereading
16	BrailleBack	Braille	Not available	Device and ereader (potential conflict). Touch.	Input and output	Required to access Bluetooth Braille Display. Braille users do not tend to use refreshable Braille Displays to read large amounts of text, it is used for correcting text or for specific navigation.
17	Colour Inversion On/Off	Invert Colours On/Off	High Contrast	Device and ereader (potential conflict). Viewing screen.	Output	This enables navigation menus to have a black background. Potential UA conflict.

Appendix E: Detailed mapped core device accessibility settings

No.	Android Nexus 5	iPhone 6	Windows Phone 8.1	Framework	Input Output	Relevance to HEI ereading
18	Switch Access On/Off	Switch Control On/Off	Not available	Device. Touch.	Input and output	This is required for navigation within the OS and the UA and between the two.
19	Scanning highlight style	Scanning Style	Not available	Device and ereader (potential conflict). Viewing screen.	Output	This enables the user to personalise the focus colour of the scan.
20	Auto-scan	Auto Scanning	Not available	Device and ereader (potential conflict). Viewing screen.	Output	This provides the standard automated scanning from menu item to men item or icon to icon. Intervention would be required when reading the econtent.

Appendix E: Detailed mapped core device accessibility settings

No.	Android Nexus 5	iPhone 6	Windows Phone 8.1	Framework	Input Output	Relevance to HEI ereading
21	Step Scanning	Manual Scanning	Not available	Device and ereader (potential conflict). Viewing screen and touch.	Input and output	In this instance one switch enables selection by moving focus the other switch enables activation of the focused item and would be useful within the econtent itself.
22	Option Scanning	Group Items On/Off	Not available	Device and ereader (potential conflict). Viewing screen and touch.	Input and output	This enables the user to group items and to apply a single switch command to activate the group. It is useful within the ereader and the econtent.

Appendix E: Detailed mapped core device accessibility settings

No.	Android Nexus 5	iPhone 6	Windows Phone 8.1	Framework	Input Output	Relevance to HEI ereading
23	Auto-scan time	Auto Scanning Time	Not available	Device and ereader (potential conflict). Viewing screen.	Output	This would be required to set the scan time in seconds, and would mainly be required in the OS and UA navigation menus.
24	Touch and Hold Delay	Hold Duration On/Off	Not available	Device and ereader (potential conflict). Touch.	Input and output	This prevents unintentional touches of the screen from activating menu items or icons. This would be required in both the OS and UA menu items. It would also be required in the econtent to prevent reading focus to change

Appendix E: Detailed mapped core device accessibility settings

						accidentally.
No.	Android Nexus 5	iPhone 6	Windows Phone 8.1	Framework	Input Output	Relevance to HEI ereading
25	Manage Gestures	Gestures	Limited	Device. Touch.	Input	Managing custom gestures or having access to a reminder list of available gestures is essential, particularly for navigation in the OS and the UA.
26	Single Tap Selection	Tap Behaviour	Not available	Device and ereader (potential conflict). Touch.	Input	This would be required in order to speed up navigation and to get to the econtent faster.

Appendix E: Detailed mapped core device accessibility settings

No.	Android Nexus 5	iPhone 6	Windows Phone 8.1	Framework	Input Output	Relevance to HEI ereading
29	Auto-rotate screen	Rotate Screen	Screen Rotation	Device. Viewing screen.	Output	Reading in landscape mode is better at sentence level and reading in portrait mode is better for paragraphs.
30	Vibration Feedback	Vibration On/Off	Vibrate - when using navigation keys	Device. Touch.	Output	Haptic feedback will help users in the OS menus and UA reading menus to be aware of an activated item.
31	Caption On/Off	Closed Captions + SDH On/Off	Browser Captions On/Off	Ereader. Viewing screen.	Output	Multimedia content such as videos, audio files and animations are not uncommon in etexts.

Appendix E: Detailed mapped core device accessibility settings

No.	Android Nexus 5	iPhone 6	Windows Phone 8.1	Framework	Input Output	Relevance to HEI ereading
32	Caption Style	Style	Font	Ereader. Viewing screen.	Input and output	Multimedia content such as videos, audio files and animations are not uncommon in etexts.
33	Text Size (multimedia)	Size	Text	Device and ereader (potential conflict). Viewing screen.	Input and output	Multimedia content such as videos, audio files and animations are not uncommon in etexts.
34	White on Black (Default) (multimedia)	White (Default)	Background	Device and ereader (potential conflict). Viewing screen.	Input and output	Multimedia content such as videos, audio files and animations are not uncommon in etexts.

Appendix E: Detailed mapped core device accessibility settings

No.	Android Nexus 5	iPhone 6	Windows Phone 8.1	Framework	Input Output	Relevance to HEI ereading
35	Accessibility Shortcut On/Off	Accessibility Shortcut On/Off	Narrator quick launch	Device. Touch and viewing screen.	Input and output	This will increase speed and reduce the number of steps required for the print impaired reader to go from Discovery through the OS to the econtent.
36	Google Keyboard	Keyboards	Keyboard	Device. Touch and viewing screen.	Input and output	This enables the user to change the keyboard language and would be required for searching and annotations.

Appendix E: Detailed mapped core device accessibility settings

No.	Android Nexus 5	iPhone 6	Windows Phone 8.1	Framework	Input Output	Relevance to HEI ereading
37	Text Correction	Auto Correction	Auto Correction	Discovery and ereader. Viewing screen and potential alternative access.	Output	Required when annotating or searching for an etext. Increases the speed of input.
38	Auto Capitilisation On/Off	Auto Capitilisation On/Off	Auto Capitilisation On/Off	Ereader. Viewing screen.	Output	Required when annotating an etext. Increases the speed of input.
39	Colour Correction On/Off	Greyscale	Available by downloading third party apps.	Device and ereader (potential conflict). Viewing screen.	Output	This enables the user to alter on screen colours to accommodate colour blindness and would be required in the OS and UA menus and the econtent.

Appendix E: Detailed mapped core device accessibility settings

No.	Android Nexus 5	iPhone 6	Windows Phone 8.1	Framework	Input Output	Relevance to HEI ereading
40	Local Context Menu On/Off	Rotor (Turn Gesture)	Not available	Device. Viewing screen and touch.	Input and output	This enables the user global command of accessibility settings and is useful for ereading but only if the UA is able to recognise this is available on the device.
41	Line Granularity	Lines	Not available	Ereader. Viewing screen.	Input and output	If this global functionality is able to access the econtent it will allow the user to read by line.
42	Word Granularity	Words	Not available	Ereader. Viewing screen.	Input and output	If this global functionality is able to access the econtent it will allow the user to read by word.

Appendix E: Detailed mapped core device accessibility settings

No.	Android Nexus 5	iPhone 6	Windows Phone 8.1	Framework	Input Output	Relevance to HEI ereading
43	Character Granularity	Characters	Not available	Ereader. Viewing screen.	Input and output	If this global functionality is able to access the econtent it will allow the user to read by character.
44	Links Menu	Links	Not available	Ereader. Viewing screen, audio and touch via moving focus.	Input and output	If this global functionality is able to access the econtent it will allow the user to read the available links in the etext.
45	English (United Kingdom)	English (UK)	English (United Kingdom)	Device and ereader (potential conflict). Viewing screen and audio.	Input	This helps with localisation and provides speech output in the required language if it is available for the device.

Appendix E: Detailed mapped core device accessibility settings

No.	Android Nexus 5	iPhone 6	Windows Phone 8.1	Framework	Input Output	Relevance to HEI ereading
46	System Updates	Software Update	Phone Update	Device and ereader (potential conflict). Viewing screen and audio.	Input and output	Required for the app to request OS permissions.

Appendix F Detailed mapped core user agent (UA) accessibility settings

The following 23 pages are a summarised version of the mapped core UA accessibility settings. The full dataset for the detailed mapped core UA accessibility settings can be found in: N.E. (2019) Dataset for: Automatically evaluating the mobile web accessibility of Higher Education electronic texts for print impairments. University of Southampton doi: 10.5258/SOTON/D1064 [Dataset] under 'CoreMappedAccessibilitySettings.xlsx'.

The means for shortlisting the UA's can be found in: N.E. (2019) Dataset for: Automatically evaluating the mobile web accessibility of Higher Education electronic texts for print impairments. University of Southampton doi: 10.5258/SOTON/D1064 [Dataset] under 'SelectingUserAgentsFinal.xlsx'.

Appendix F: Detailed mapped core user agent (UA) accessibility settings

Table F1: Ten mobile ereader applications mapped to core settings relating to accessibility and reading etexts in HE.

No.	Feature	Adobe Acrobat Reader	Adobe Digital Editions	Blio	Bluefire Reader	Gitden	Ideal Group Reader	Kobo	Lektz	VI Reader	Voice Dream	Total	%
1	About												
1.1	About	0	1	1	1	0	0	1	0	0	1	5	50
2	Account												
2.1	Register	1	1	1	1	1	0	1	1	0	1	8	80
2.2	Sign In	1	1	1	1	1	1	1	1	1	1	10	100
2.3	Sign Out	1	1	1	1	1	0	1	1	0	0	7	70
3	Annotation												
3.1	Notes	0	0	0	0	1	1	0	1	0	0	3	30
3.2	Manage Notes	0	0	0	0	0	1	0	0	0	0	1	10
3.3	Comment	1	0	0	0	0	1	0	0	0	0	2	20
3.4	Export notes	0	0	0	0	1	1	0	0	0	0	2	20
3.5	Highlight	1	1	0	1	0	0	0	0	0	1	4	40
3.6	Highlight colour	0	0	0	0	0	1	0	0	0	1	2	20

Appendix F: Detailed mapped core user agent (UA) accessibility settings

No.	Feature	Adobe Acrobat Reader	Adobe Digital Editions	Blio	Bluefire Reader	Gitden	Ideal Group Reader	Kobo	Lektz	VI Reader	Voice Dream	Total	%
3	Annotation (continued).												
3.7	Export highlights	0	0	0	0	0	0	0	0	0	1	1	10
3.8	Highlight background colour	0	0	0	0	0	1	0	0	0	1	2	20
3.9	Annotation author	1	0	0	0	0	0	0	0	0	0	1	10
3.10	Images	0	0	0	0	1	0	0	0	0	0	1	10
3.11	Tables	0	0	0	0	1	0	0	0	0	0	1	10
3.12	Copy	0	0	0	0	0	1	0	0	0	0	1	10
3.13	Lookup	0	0	0	0	0	1	0	0	0	0	1	10
3.14	Spell	0	0	0	0	0	1	0	0	0	0	1	10
4	Bookmarking												
4.1	Bookmarks	1	1	1	1	1	1	1	1	1	1	10	100
4.2	List bookmarks	0	0	0	0	0	1	0	0	0	0	1	10
4.3	Manage bookmarks	0	0	0	0	0	1	0	0	0	0	1	10

Appendix F: Detailed mapped core user agent (UA) accessibility settings

No.	Feature	Adobe Acrobat Reader	Adobe Digital Editions	Blio	Bluefire Reader	Gitden	Ideal Group Reader	Kobo	Lektz	VI Reader	Voice Dream	Total	%
4	Bookmarking (continued).												
4.4	Mark as finished	0	0	0	0	0	0	1	0	0	0	1	10
5	Discovery												
5.1	Categories	0	0	0	0	0	0	0	1	0	0	1	10
5.2	OPDS Catalogue, Free ebooks, Feedbooks Bookshare	0	0	0	0	1	1	1	1	0	1	5	50
5.3	Sign In Feedbooks	0	0	0	1	0	0	0	0	0	0	1	10
5.4	Register Feedbooks	0	0	0	1	0	0	0	0	0	0	1	10
5.5	3G/4G Warning	0	0	1	0	0	0	0	0	0	0	1	10
5.6	Store	0	0	1	0	0	0	0	1	0	0	2	20
5.7	Best Seller	0	0	0	0	0	0	0	1	0	0	1	10
5.8	Bookstore (with Talkback)	0	0	1	0	0	0	0	0	0	0	1	10

No.	Feature	Adobe Acrobat Reader	Adobe Digital Editions	Blio	Bluefire Reader	Gitden	Ideal Group Reader	Kobo	Lektz	VI Reader	Voice Dream	Total	%
5	Discovery (continued).												
5.9	Refresh	0	0	0	0	1	0	0	0	0	0	1	10
5.10	Publishers	0	0	0	0	0	0	0	1	0	0	1	10
6	Metadata												
6.1	Copy & Paste Permissions, opens every device	0	0	0	1	0	0	0	0	0	0	1	10
7	Format support												
7.1	Non DRM Protected PDF	1	1	0	1	1	0	1	1	0	1	7	70
7.2	DRM Protected PDF	0	1	0	0	0	0	1	0	0	0	2	20
7.3	Non DRM Protected ePub3	0	1	1	1	1	1	1	1	0	1	8	80
7.4	DRM Protected ePub3	0	1	0	0	0	0	0	0	0	0	1	10

Appendix F: Detailed mapped core user agent (UA) accessibility settings

No.	Feature	Adobe Acrobat Reader	Adobe Digital Editions	Blio	Bluefire Reader	Gitden	Ideal Group Reader	Kobo	Lektz	VI Reader	Voice Dream	Total	%
8	Help documentation												
8.1	Help	1	0	1	1	1	1	1	0	1	1	8	80
8.2	Save error logs	0	0	0	0	0	0	1	0	0	0	1	10
8.3	Library help	0	0	0	0	0	0	1	0	0	0	1	10
8.4	Notifications	0	0	1	0	0	0	1	0	0	1	2	20
8.5	Ask developer	0	0	0	0	1	0	0	0	0	0	1	10
8.6	Feedback	0	0	0	0	0	1	1	0	0	0	2	20
8.7	Report a problem	0	0	0	0	0	0	1	0	0	0	1	10
9	Printing												
9.1	Print	1	0	0	0	0	0	0	0	0	0	1	10
10	Library (bookshelf in the application)												
10.1	Bookshelf	1	1	1	1	1	1	1	1	0	1	9	90
10.2	Playlist	0	0	0	0	0	0	0	0	0	1	1	10
10.3	Un-categorised	0	0	0	0	0	0	0	0	0	1	1	10
10.4	Unread	0	0	0	0	0	0	0	0	0	1	1	10

Appendix F: Detailed mapped core user agent (UA) accessibility settings

No.	Feature	Adobe Acrobat Reader	Adobe Digital Editions	Blio	Bluefire Reader	Gitden	Ideal Group Reader	Kobo	Lektz	VI Reader	Voice Dream	Total	%
10	Library continued (bookshelf in the application)												
10.5	Search bookshelf	0	0	0	1	1	1	1	0	0	1	5	50
10.6	Additional book info.	0	0	0	1	0	0	0	0	0	0	1	10
10.7	Search library (without Talkback)	0	0	1	0	0	0	0	0	0	0	1	10
10.8	Search library (with Talbabck)	0	0	1	0	0	0	0	0	0	0	1	10
11	Reading												
11.1	Interactive EPUB3	0	0	0	0	0	1	0	0	0	0	1	10
11.2	Silent mode	0	0	0	0	0	1	0	0	0	0	1	10
11.3	Use recorded voice	0	0	0	0	0	1	0	0	0	0	1	10

Appendix F: Detailed mapped core user agent (UA) accessibility settings

No.	Feature	Adobe Acrobat Reader	Adobe Digital Editions	Blio	Bluefire Reader	Gitden	Ideal Group Reader	Kobo	Lektz	VI Reader	Voice Dream	Total	%
11	Reading continued.												
11.4	Reading options reset	0	0	0	0	1	0	0	0	0	0	1	10
11.5	Page view (EPUB3)	0	0	0	0	1	0	0	0	0	0	1	10
11.6	Continuous scrolling	1	0	0	0	0	0	0	0	0	1	2	20
11.7	Continuous reading (TTS)	0	0	1	0	0	0	0	0	0	1	2	20
11.8	Single page	1	0	1	0	0	0	0	0	0	1	3	30
11.9	Page transition	0	0	0	0	1	1	1	1	0	0	4	40
11.10	Page turn by tapping	0	0	0	1	1	0	1	0	0	0	3	30
11.11	Show page number (EPUB3)	0	0	0	1	0	0	0	0	0	0	1	10
11.12	Automatic orientation	0	0	0	0	0	0	1	0	0	0	1	10

Appendix F: Detailed mapped core user agent (UA) accessibility settings

No.	Feature	Adobe Acrobat Reader	Adobe Digital Editions	Blio	Bluefire Reader	Gitden	Ideal Group Reader	Kobo	Lektz	VI Reader	Voice Dream	Total	%
11	Reading continued.												
11.13	Orientation lock	0	0	0	1	1	0	1	0	0	0	3	30
11.14	Screen lock override	0	0	0	1	0	0	0	0	0	0	1	10
11.15	Override formatting	0	0	0	1	0	0	0	0	0	0	1	10
11.16	Change direction of scroll	0	0	0	0	0	0	0	0	1	0	1	10
11.17	PDF (layout)	1	1	0	0	0	0	0	0	0	1	3	30
11.18	Reading mode (PDF)	1	1	0	0	0	0	0	0	0	1	3	30
11.19	Zoom Image/ Table	0	0	0	0	1	0	0	0	0	0	1	10
11.20	Zoom (PDF)	1	1	0	0	0	0	0	0	0	0	2	20
11.21	Day	1	1	1	0	0	1	1	0	0	1	6	60
11.22	Night	1	1	1	1	0	1	1	0	1	1	7	70
11.23	Sepia	0	0	0	0	0	0	1	0	1	0	2	20

Appendix F: Detailed mapped core user agent (UA) accessibility settings

No.	Feature	Adobe Acrobat Reader	Adobe Digital Editions	Blio	Bluefire Reader	Gitden	Ideal Group Reader	Kobo	Lektz	VI Reader	Voice Dream	Total	%
11	Reading continued.												
11.24	Custom (no yellow text on black)	0	0	0	0	0	0	0	0	0	1	1	10
11.25	Text preview	0	1	1	1	0	1	1	1	0	0	6	60
11.26	Font size (EPUB3)	0	1	1	1	1	1	1	1	1	1	9	90
11.27	Import fonts (EPUB3)	0	0	0	0	1	0	0	0	0	0	1	10
11.28	Font style (EPUB3)	0	0	1	1	0	0	1	1	1	1	6	60
11.29	Line spacing (EPUB3)	0	0	1	1	1	1	0	0	1	1	6	60
11.30	Word spacing (EPUB3)	0	0	0	0	0	1	0	0	0	0	1	10
11.31	Character spacing (EPUB3)	0	0	0	0	0	1	0	0	0	1	2	20

Appendix F: Detailed mapped core user agent (UA) accessibility settings

No.	Feature	Adobe Acrobat Reader	Adobe Digital Editions	Blio	Bluefire Reader	Gitden	Ideal Group Reader	Kobo	Lektz	VI Reader	Voice Dream	Total	%
11	Reading continued.												
11.32	Adjust margin (EPUB3)	0	1	0	1	0	0	0	0	0	1	3	30
11.33	Text alignment (EPUB3)	0	0	0	1	1	0	0	1	0	0	3	30
11.34	Theme (EPUB3)	0	0	0	1	0	1	0	0	0	0	2	20
11.35	Text colour (EPUB3)	0	0	0	1	0	1	0	0	1	0	3	30
11.36	Background colour (EPUB3)	0	0	0	1	1	1	0	1	1	1	6	60
11.37	Dyswebxia (default settings)	0	0	0	0	0	1	0	0	0	0	1	10
11.38	Highlights (EPUB3)	0	0	0	1	0	0	0	0	0	0	1	10
11.39	Link colour (EPUB3)	0	0	0	1	1	0	0	0	0	0	2	20

Appendix F: Detailed mapped core user agent (UA) accessibility settings

No.	Feature	Adobe Acrobat Reader	Adobe Digital Editions	Blio	Bluefire Reader	Gitden	Ideal Group Reader	Kobo	Lektz	VI Reader	Voice Dream	Total	%
11	Reading continued.												
11.40	Brightness slider	0	1	0	1	1	0	1	1	1	0	6	60
11.41	Read aloud (TTS)	0	0	1	0	1	1	0	0	0	1	4	40
11.42	Voice	0	0	0	0	0	0	0	0	0	1	1	10
11.43	Manage my voices	0	0	0	0	0	0	0	0	0	1	1	10
11.44	Previous item	0	0	0	0	0	0	0	0	0	1	1	10
11.45	Play	0	0	0	0	0	0	0	0	0	1	1	10
11.46	Next item	0	0	0	0	0	0	0	0	0	1	1	10
11.47	Go to percentage	0	0	0	0	0	0	0	0	0	1	1	10
11.48	Select navigation unit	0	0	0	0	0	0	0	0	0	1	1	10
11.49	Talback reads econtent	0	0	0	0	0	1	0	1	0	0	2	20

Appendix F: Detailed mapped core user agent (UA) accessibility settings

No.	Feature	Adobe Acrobat Reader	Adobe Digital Editions	Blio	Bluefire Reader	Gitden	Ideal Group Reader	Kobo	Lektz	VI Reader	Voice Dream	Total	%
11	Reading continued.												
11.50	Show spoken word	0	0	0	0	0	0	0	0	0	1	1	10
11.51	Show spoken line	0	0	0	0	0	0	0	0	0	1	1	10
11.52	Cursor position	0	0	0	0	0	0	0	0	0	1	1	10
11.53	Highlight style margin/text	0	0	0	0	0	0	0	0	0	1	1	10
11.54	Lines visible (EPUB3)	0	0	0	0	0	0	0	0	0	1	1	10
11.55	Pitch 1.0+	0	0	0	0	1	0	0	0	0	0	1	10
11.56	Rate 1.0 --+	0	0	0	0	1	0	0	0	0	0	1	10
11.57	Android context menu	0	0	1	0	0	0	0	0	0	0	1	10
11.58	External keyboard	0	0	1	0	0	0	0	0	0	0	1	10

Appendix F: Detailed mapped core user agent (UA) accessibility settings

No.	Feature	Adobe Acrobat Reader	Adobe Digital Editions	Blio	Bluefire Reader	Gitden	Ideal Group Reader	Kobo	Lektz	VI Reader	Voice Dream	Total	%
11	Reading continued.												
11.59	Vertical writing (Japanese)	0	0	0	0	1	0	0	0	0	0	1	10
11.60	Right to left (EPUB3)	0	0	0	0	0	0	0	1	0	0	1	10
11.61	Disable sleep	0	0	0	0	0	0	0	1	0	0	1	10
11.62	Walking mode	0	0	0	0	0	0	0	1	0	0	1	10
12	Search etext												
12.1	Search book	1	1	1	1	1	0	1	1	0	1	8	80
13	Scanning and OCR												
13.1	Scan picture to PDF	1	0	0	0	0	0	0	0	0	0	1	10
14	Social media												
14.1	Share	1	0	0	0	0	0	1	1	0	0	3	30

Appendix F: Detailed mapped core user agent (UA) accessibility settings

No.	Feature	Adobe Acrobat Reader	Adobe Digital Editions	Blio	Bluefire Reader	Gitden	Ideal Group Reader	Kobo	Lektz	VI Reader	Voice Dream	Total	%
14	Social media continued.												
14.2	Share document cloud link	1	0	0	0	0	0	0	0	0	0	1	10
15	Storage												
15.1	Import book	0	0	1	1	1	1	1	1	1	0	7	70
15.2	Manage downloads	0	0	0	0	0	0	1	0	0	0	1	10
15.3	Manage my voices (TTS)	0	0	0	0	0	0	0	0	0	1	1	10
15.4	Recent	1	0	0	0	0	0	0	0	0	0	1	10
15.5	Local	1	0	0	0	0	0	0	0	0	0	1	10
15.6	Document cloud	1	0	0	0	0	0	0	0	0	0	1	10
15.7	Dropbox	1	0	0	0	0	0	0	0	0	0	1	10
16	Navigation												
16.1	Page location sync.	0	0	0	1	0	0	0	0	0	0	1	10

Appendix F: Detailed mapped core user agent (UA) accessibility settings

No.	Feature	Adobe Acrobat Reader	Adobe Digital Editions	Blio	Bluefire Reader	Gitden	Ideal Group Reader	Kobo	Lektz	VI Reader	Voice Dream	Total	%
16	Navigation continued.												
16.2	Contents (TOC)	1	1	1	1	1	1	1	1	1	1	10	100
16.3	Go to page	0	1	0	0	0	0	0	0	0	0	1	10
16.4	Progress slider	1	1	1	1	1	0	1	1	0	1	8	80
17	User behaviour												
17.1	Provide usage data	1	0	0	0	0	0	1	1	0	0	3	30
17.2	Share feedback	1	0	0	0	0	0	0	0	0	1	2	20
17.3	Write a review	0	0	0	0	0	0	0	0	0	1	1	10
Total		30	24	29	38	37	38	36	30	14	51	327	

Table F2: Core mapped mobile browser settings relating to HE and accessibility

No.	Feature	Chrome	Firefox	Opera	Total	%
1	About					
1.1	About	1	1	1	3	100
2	Account					
2.1	Sign in	1	1	1	3	100
3	Gesture & sonar (sonar is navigation by voice within the mobile browser)					
3.1	Gesture	0	0	0	0	0
3.2	Sonar	0	0	0	0	0
4	Help					
4.1	FAQs	0	1	1	2	66.67
4.2	Feedback	0	1	1	2	66.67
4.3	Introduction	0	0	1	1	33.33
5	Text size					
5.1	Text size/text size slider	1	1	0	2	66.67
6	Word wrap					
6.1	Text wrap	0	0	1	1	33.33
6.2	Page zoom	1	1	1	3	100
6.3	Open pages in overview	0	0	0	0	0
6.4	Pinch zoom button	0	0	0	0	0

Appendix F: Detailed mapped core user agent (UA) accessibility settings

No.	Feature	Chrome	Firefox	Opera	Total	%
7	Voice					
7.1	Voice input (within the address bar)	0	1	0	1	33.33

Table F3: Core mapped online ereader settings relating to HE and accessibility

No.	Feature	Readium (EPUB3 Firefox)	Bureau Van Dijk (EPUB3 – Firefox)	Firefox PDF Cloud viewer add on	Total	%
1	About					
1.1	About	1	0	1	2	66.67
2	Accounts					
2.1	Sign in	0	1	0	1	33.33
3	Annotation					
3.1	Highlights	0	1	0	1	33.33
3.2	H = Highlight current selection	0	1	0	1	33.33
3.3	E = Edit current note	0	1	0	1	33.33
3.4	Delete = Delete current highlight	0	1	0	1	33.33
4	Bookmarks					
4.1	Bookmarks	0	1	0	1	33.33
5	Search Metadata					
5.1	Relevancy	0	1	0	1	33.33
5.2	New to old	0	1	0	1	33.33
5.3	Old to new	0	1	0	1	33.33

Appendix F: Detailed mapped core user agent (UA) accessibility settings

No.	Feature	Readium (EPUB3 Firefox)	Bureau Van Dijk (EPUB3 – Firefox)	Firefox PDF Cloud viewer add on	Total	%
5	Search Metadata continued.					
5.4	Authors	0	1	0	1	33.33
5.5	Publishers	0	1	0	1	33.33
5.6	Languages	0	1	0	1	33.33
6	Additional keyboard shortcuts					
6.1	T = Table of contents	1	1	0	2	66.67
6.2	I = Thumbnails	0	1	0	1	33.33
6.3	N = Highlights	0	1	0	1	33.33
6.4	S = Search	0	1	0	1	33.33
6.5	F = Fullscreen	0	1	0	1	33.33
6.6	CTRL + C = Copy Selection	0	1	0	1	33.33
6.7	B - Bookmark	0	1	0	1	33.33
6.8	Left arrow = Previous page	1	1	0	2	66.67
6.9	Right Arrow = Next Page	1	1	0	2	66.67
6.10	'-' = Zoom out	0	1	1	2	66.67
6.11	'+' = Zoom in	0	1	1	2	66.67

No.	Feature	Readium (EPUB3 Firefox)	Bureau Van Dijk (EPUB3 – Firefox)	Firefox PDF Cloud viewer add on	Total	%
6	Additional keyboard shortcuts continued.					
6.12	Page 1/x	0	0	1	1	33.33
6.13	Long Press - Select All	0	0	1	1	33.33
6.14	Reset all keyboard shortcuts	1	0	0	1	33.33
6.15	o = Show Settings Modal	1	0	0	1	33.33
6.16	s = Settings Modal Save	1	0	0	1	33.33
6.17	c = Settings Modal Close	1	0	0	1	33.33
6.18	1 = Previous Page (Access Key)	1	0	0	1	33.33
6.19	2 = Next Page (Access Key)	1	0	0	1	33.33
6.20	v = Show Toolbar	1	0	0	1	33.33
6.21	x = Hide Toolbar	1	0	0	1	33.33
6.22	b = Library	1	0	0	1	33.33
6.23	n = Arabian Nights (Night mode)	1	0	0	1	33.33
6.24	r = Escape current audio context	1	0	0	1	33.33
6.25	k = Reset Audio Playback to Normal Speed	1	0	0	1	33.33
6.26	a = Mute/Unmute Audio	1	0	0	1	33.33

Appendix F: Detailed mapped core user agent (UA) accessibility settings

No.	Feature	Radium (EPUB3 Firefox)	Bureau Van Dijk (EPUB3 – Firefox)	Firefox PDF Cloud viewer add on	Total	%
6	Additional keyboard shortcuts continued.					
6.27	g = Show advanced audio controls	1	0	0	1	33.33
7	Reading					
7.1	Display format: Single	1	0	0	1	33.33
7.2	Display format: Double page	1	0	0	1	33.33
7.3	Scroll mode: Default	1	0	0	1	33.33
7.4	Scroll mode: Document	1	0	0	1	33.33
7.5	Scroll mode: Continuous	1	0	0	1	33.33
7.6	Text preview	1	0	0	1	33.33
7.7	Font size slider	1	0	0	1	33.33
7.8	Margins slider	0	1	1	2	66.67
7.9	Text and background colour theme	0	1	1	2	66.67
7.10	Font	0	0	1	1	33.33
7.11	Display page labels check/uncheck	0	0	1	1	33.33
7.12	Pause = Skip Section	0	0	1	1	33.33
7.13	Play/Pause	1	1	0	2	66.67

No.	Feature	Radium (EPUB3 Firefox)	Bureau Van Dijk (EPUB3 – Firefox)	Firefox PDF Cloud viewer add on	Total	%
7	Reading continued.					
7.14	Play/Pause	1	1	0	2	66.67
7.15	Previous Audio Phrase	1	1	0	2	66.67
7.16	Next Audio Phrase	1	1	0	2	66.67
7.17	Increase audio volume	1	1	0	2	66.67
7.18	Decrease Audio Volume	1	1	0	2	66.67
7.19	Increase Audio Playback Rate	1	1	0	2	66.67
7.20	Decrease Audio Playback Rate	1	1	0	2	66.67
7.21	Enter/Exit Fullscreen	1	1	0	2	66.67
7.22	Forward Arrow	0	0	1	1	33.33
7.23	Backward Arrow	0	0	1	1	33.33
7.24	Thumbnails (eg. front matter)	0	0	1	1	33.33
8	Search etext					
8.1	Search	0	1	0	1	33.33

Appendix F: Detailed mapped core user agent (UA) accessibility settings

No.	Feature	Readium (EPUB3 Firefox)	Bureau Van Dijk (EPUB3 – Firefox)	Firefox PDF Cloud viewer add on	Total	%
9	Table of contents (TOC)					
9.1	Table of contents	0	1	0	1	33.33

Appendix G Framework development

G.1 Academic and student use case walkthrough

The following provides a breakdown of an academic and student use case walkthrough for an HEI library web portal, including the download and subsequent reading of an etext for those with print impairments. The web portal referred to here was the University of Southampton SUSSED hand-off to the Hartley Library portal so that an ACM publication could be downloaded and read on a mobile device.

G.1.1 Blind and visually impaired – screen reading

Using a Nexus 5 Android version 6.0.1 using Talkback version 5.0.4, Firefox Mobile Browser 50.0.2 – using the PDF Cloud Viewer and a Bluetooth 3.0 Keyboard. The Bluetooth keyboard was setup to allow arrow and tab keys to move focus. The PDF Cloud Viewer did not work and the Google Drive PDF viewer was used instead. This only allowed the PDF to be viewed and no other functionality was available. When Talkback is activated the Global and Context Menus can be accessed with swipe gestures. Swipe Down and Right brings up the Global Context Menu. Swipe Up and Right brings up the Local Context Menu and is dependent upon what is selected.

Discovery:

1. Navigate to and open Firefox Mobile Browser using focus.
2. Input the term SUSSED using Bluetooth keyboard or use Google Search voice recognition to enter the term SUSSED.
3. Navigate to SUSSED link and double tap or press enter on Bluetooth keyboard.
4. Swipe to move focus to username box.
5. Type in Username.
6. Swipe to move focus to Password.
7. Type in Password then swipe to move focus to Sign In. Speak password is a setting available on the Android.
8. Double tap or press enter to sign in.
9. Navigate to Library link and double tap or press enter.
10. Navigate to Resources link and double tap or press enter.
11. Navigate to ACM Digital Library and double tap or press enter.
12. Navigate to ACM DL search entry box and double tap or press enter.

Search metadata:

1. Type in the text "Evaluating the mobile web accessibility of electronic text". No microphone is available in the ACM search box to enable voice recognition.
2. Swipe to move focus to the Search button and double tap or press enter.
3. Navigate to the paper and double tap or press enter. I tried using the quick navigation keys to get to the paper but ended up having to sequentially go through every link using the arrow keys until I got to the paper. It maybe that I was not using the correct shortcut key on the keyboard to skip to content.

Econtent format:

1. Navigate to the PDF link and double tap or press enter.
2. Dialogue window: Open this document in an online viewer. Navigate to Ok and double tap or press enter.

Ereader:

1. No preview available. DRM protected PDF.
2. Disable Cloud Viewer Add On. Double tap or press enter.
3. Dialogue window complete action using:
 - a. Firefox Download
 - b. (Google) Drive PDF Viewer
 - c. eBook Reader
 - d. Download to Bluefire
4. Just Once/Always
5. Navigate to Google Drive PDF Viewer and double tap or press enter.
6. Alternatively navigate to the three dot menu. Double tap or press enter.
7. Navigate to and select 'Open with...' or 'Print' then double tap or press enter.
8. Open with...
 - a. eBook Reader
 - b. Lektz
 - c. Voice Dream Reader
 - d. Adobe acrobat
 - e. PDF Viewer
 - f. Foxit PDF
 - g. Download to Bluefire
 - h. Digital Editions
 - i. Gitden Reader
 - j. Amazon Kindle
 - k. PDF Plugin for Gitden.

Econtent:

1. Talkback reads aloud the entire paper. There is no media overlay or any further control within the PDF.

2. Print dialogue: Navigate to all printers then double tap or press enter. Save to Google Drive Cloud Print

G.1.2 Blind and visually impaired – high contrast

Using a Nexus 5 Android version 6.0.1 and the Firefox Mobile Browser 50.0.2 – using the Google Drive PDF viewer and a Bluetooth 3.0 Keyboard. The accessibility setting colour inversion was used.

Discovery:

1. Navigate to and open Firefox Mobile Browser. The device menus, including on screen keyboard, are white text on a black background. The mobile browser menus are white text on black background.
2. Type in SUSSED using Bluetooth or on screen keyboard or use Google Search voice recognition to enter the term SUSSED into the mobile browser.
3. Tap the SUSSED link.
4. The contrast of the username and password field box in colour inversion will require a colour contrast test for the SUSSED website. Images are also in negative.
5. Navigate to the username box.
6. Type in Username.
7. Navigate to the password box.
8. Type in Password. Speak password is a setting available on the Android.
9. Tap sign in button to sign in.
10. Navigate to Library tab and tap to enter.
11. Navigate to Resources link and tap to enter.
12. Navigate to A-Z List of e-Resources and tap to enter.
13. Navigate to ACM Digital Library and tap to enter. The ACM website is non-responsive.
14. Navigate to ACM DL search entry box tap to enter. The search entry box will require a contrast check when using colour inversion. The drop down menu with previous search terms appears white text on a black background. The search button is difficult to read when using colour inversion.

Search metadata:

1. Type in the text “Evaluating the mobile web accessibility of electronic text” either using the Bluetooth keyboard or the on screen keyboard. No microphone is available in the ACM search box to enable voice recognition.
2. Tap the search button.
3. Tap the papers URL. The resulting page is still white text on a black background with URL’s in green.

Econtent format:

1. Tap the PDF download URL.
2. Dialogue window complete action using:
 - a. Firefox Download
 - b. (Google) Drive PDF Viewer
 - c. eBook Reader
 - d. Download to Bluefire
3. Just Once/Always

Ereader:

1. Navigate to Google Drive PDF Viewer and double tap to enter.
2. Alternatively navigate to the three dot menu. Tap or press enter.
3. Navigate to and select 'Open with...' or 'Print' then double tap or press enter.
4. Open with...
 - a. eBook Reader
 - b. Lektz
 - c. Voice Dream Reader
 - d. Adobe acrobat
 - e. PDF Viewer
 - f. Foxit PDF
 - g. Download to Bluefire
 - h. Digital Editions
 - i. Gitden Reader
 - j. Amazon Kindle
 - k. PDF Plugin for Gitden.

Econtent:

1. The paper opens in Google Drive PDF viewer with white text on a black background.

G.1.3 Blind and visually impaired – colour blindness

Using a Nexus 5 Android version 6.0.1 and the Firefox Mobile Browser 50.0.2 – using the Google Drive PDF viewer and a Bluetooth 3.0 Keyboard. The accessibility setting Colour correction was used. Deuteranomaly (red-green) was selected.

Discovery:

1. Navigate to and open Firefox Mobile Browser. The device and mobile browser menus, including on screen keyboard, alter in terms of red-green.
2. Type in SUSSED using Bluetooth or on screen keyboard to enter the term SUSSED into the mobile browser.
3. Tap the SUSSED link. The SUSSED website is displayed altering red-green, particularly noticeable on images and icons.
4. Navigate to the username box.
5. Type in Username.
6. Navigate to the password box.
7. Type in Password.
8. Tap sign in button to sign in.
9. Navigate to Library tab and tap to enter.
10. Navigate to Resources link and tap to enter. The LibGuides website alters in terms of red-green.
11. Navigate to A-Z List of e-Resources and tap to enter.
12. Navigate to ACM Digital Library and tap to enter. The ACM website is non-responsive but alters in terms of red-green.
13. Navigate to ACM DL search entry box tap to enter. The ACM search button is difficult to read when Colour correction is on.

Search metadata:

1. Type in the text “Evaluating the mobile web accessibility of electronic text” either using the Bluetooth keyboard or the on screen keyboard.
2. Tap the search button.
3. Tap the papers URL.

Econtent format:

1. Tap the PDF download URL.
2. Dialogue window complete action using:
 - a. Firefox Download
 - b. (Google) Drive PDF Viewer
 - c. eBook Reader
 - d. Download to Bluefire
3. Just Once/Always.
Alters in terms of Red Green.

Ereader:

1. Navigate to Google Drive PDF Viewer and double tap to enter.
2. Alternatively navigate to the three dot menu. Tap or press enter.
3. Navigate to and select 'Open with...' or 'Print' then double tap or press enter.
4. Open with...
 - a. eBook Reader
 - b. Lektz
 - c. Voice Dream Reader
 - d. Adobe Acrobat
 - e. PDF Viewer
 - f. Foxit PDF
 - g. Download to Bluefire
 - h. Digital Editions
 - i. Gitden Reader or Open with PDF Plugin for Gitden
 - j. Amazon Kindle

Econtent:

1. The paper opens in Google Drive PDF viewer and alters in terms of red-green.

G.1.4 Blind and visually impaired – magnification gestures

Using a Nexus 5 Android version 6.0.1 and the Firefox Mobile Browser 50.0.2 – using the Google Drive PDF viewer and a Bluetooth 3.0 Keyboard. The accessibility setting Magnification gestures was used. Since the SUSSED website and ACM website are non-responsive swipe gestures are required to zoom in and pinch gestures to zoom out. By triple tapping on the home screen or the device menus the magnification works but requires three fingers to scroll. Also in the mobile browser settings Always enable zoom was activated.

Discovery:

1. Navigate to and open Firefox Mobile Browser. Triple tapping the screen magnifies the mobile browser. The three finger swipe allows the user to scroll around the screen.
2. Type in SUSSED using Bluetooth or on screen keyboard to enter the term SUSSED into the mobile browser. Triple tap magnifies the search entry box of the mobile browser.
3. Tap the SUSSED link.
4. Navigate to the username box.
5. Type in Username. The mobile browser is magnified using triple tap, but further refining of zoom is possible by using pinch and swipe gestures.
6. Navigate to the password box.
7. Type in Password.
8. Tap sign in button to sign in.
9. Navigate to Library tab and tap to enter. The mobile browser is magnified using triple tap, but further refining of zoom is possible by using pinch and swipe gestures.
10. Navigate to Resources link and tap to enter. LibGuides is magnified using triple tap, but further refining of zoom is possible by using pinch and swipe gestures.
11. Navigate to A-Z List of e-Resources URL and tap to enter.
12. Navigate to ACM Digital Library and tap to enter.
13. Navigate to ACM DL search entry box tap to enter.

Search metadata:

1. Type in the text “Evaluating the mobile web accessibility of electronic text” either using the Bluetooth keyboard or the on screen keyboard. The mobile browser is magnified using triple tap, but further refining of zoom is possible by using pinch and swipe gestures.
2. Tap the search button.
3. Tap the papers URL.

Econtent format:

1. Tap the PDF download URL. The ACM website is magnified using triple tap, but further refining of zoom is possible by using pinch and swipe gestures.
2. Dialogue window complete action using:
 - a. Firefox Download
 - b. (Google) Drive PDF Viewer
 - c. eBook Reader
 - d. Download to Bluefire
3. Just Once/Always.

The dialogue window is magnified using triple tap, but further refining of zoom is possible by using pinch and swipe gestures.

Ereader:

1. Navigate to Google Drive PDF Viewer and double tap to enter.
2. Alternatively navigate to the three dot menu. Tap or press enter.
3. Navigate to and select 'Open with...' or 'Print' then double tap or press enter.
4. Open with...
 - a. eBook Reader
 - b. Lektz
 - c. Voice Dream Reader
 - d. Adobe acrobat
 - e. PDF Viewer
 - f. Foxit PDF
 - g. Download to Bluefire
 - h. Digital Editions
 - i. Gitden Reader or PDF Plugin for Gitden
 - j. Amazon Kindle.

Econtent:

1. The paper opens in PDF viewer and magnifies with triple tap, but further refining of zoom is possible by using pinch and swipe gestures. Note: if the paper is written in columns this helps reduce horizontal scrolling because the column can be enlarged to the width of the screen.

G.1.5 Blind and visually impaired – increase font size

Using a Nexus 5 Android version 6.0.1 and the Firefox Mobile Browser 50.0.2 – using the Google Drive PDF viewer and a Bluetooth 3.0 Keyboard. The device accessibility setting large text was used for device menus. Whereas Adobe Acrobat reader reflow was used to alter font size in the PDF.

Discovery:

1. Navigate to and open Firefox Mobile Browser. Browser Navigation and search box do not increase in size when browser text size is set to Extra Large in the browser accessibility settings.
2. Type in SUSSED using Bluetooth or on screen keyboard to enter the term SUSSED into the mobile browser.
3. Tap the SUSSED link. The SUSSED website navigation bar and body text does not increase in size when the browser text size to Extra Large in the browser accessibility settings.
4. Type in Username.
5. Type in Password.
6. Tap sign in button to sign in.
7. Navigate to Library tab and tap to enter.
8. Navigate to Resources link and tap to enter. LibGuides website navigation bar and body text does not increase in size when the browser text size is set to Extra Large in the browser accessibility settings.
9. Navigate to A-Z List of e-Resources URL and tap to enter.
10. Navigate to ACM Digital Library and tap to enter. The ACM website navigation bar and body text does not increase in size when the browser text size to Extra Large in the browser accessibility settings.
11. Navigate to ACM DL search entry box tap to enter.

Search metadata:

1. Type in the text “Evaluating the mobile web accessibility of electronic text” either using the Bluetooth keyboard or the on screen keyboard.
2. Tap the search button. The results found on the ACM website are made available in Extra Large text size but the navigation links are small.
3. Tap the papers URL. The papers page is provided in Extra Large text with the abstract text reflowing. The PDF URL and other links remain small.

Econtent format:

1. Tap the PDF download URL.
2. Dialogue window complete action using:
 - a. Firefox Download
 - b. (Google) Drive PDF Viewer
 - c. eBook Reader
 - d. Download to Bluefire
3. Just Once/Always.

Ereader:

1. Navigate to Google Drive PDF Viewer and double tap to enter.
2. Navigate to the three dot menu and tap it once.
3. Navigate to and select 'Open with...' or 'Print' then tap.
4. Open with...

Select 'Adobe Acrobat' from the following list:

- a. eBook Reader
- b. Lektz
- c. Voice Dream Reader
- d. Adobe acrobat
- e. PDF Viewer
- f. Foxit PDF
- g. Download to Bluefire
- h. Digital Editions
- i. Gitden Reader or PDF Plugin for Gitden
- j. Amazon Kindle.

Econtent:

1. The paper opens in Adobe Acrobat reader. Select Reading Mode. Pinch or double tap to increase/decrease font size. If Voice Dream is used Font Size can also be adjusted for PDFs in Layout switching to Text Only (eg. reflow).

G.1.6 Dyslexia (cognitive impairment) – text to speech (TTS)

Using a Nexus 5 Android version 6.0.1 and the Firefox Mobile Browser 50.0.2 – using the Google Drive PDF viewer and a Bluetooth 3.0 Keyboard. The Graham voice installed by default into Voice Dream was used, with the speech rate set to 180 words per minute. TTS is only used as and when required. The two most distinct areas are reading the pre download abstract and within the econtent itself.

Discovery:

1. Navigate to and open Firefox Mobile Browser.
2. Type in SUSSED using Bluetooth or on screen keyboard to enter the term SUSSED into the mobile browser.
3. Tap the SUSSED link.
4. Navigate to the username box.
5. Type in Username.
6. Navigate to the password box.
7. Type in Password.
8. Tap sign in button to sign in.
9. Navigate to Library tab and tap to enter.
10. Navigate to Resources link and tap to enter.
11. Navigate to A-Z List of e-Resources URL and tap to enter.
12. Navigate to ACM Digital Library and tap to enter.
13. Navigate to ACM DL search entry box tap to enter.

Search metadata:

1. Type in the text “Evaluating the mobile web accessibility of electronic text” either using the Bluetooth keyboard or the on screen keyboard.
2. Tap the search button.
3. Tap the papers URL.
4. The papers page provides the abstract to read prior to download. TTS apps are available that allow the user to convert text directly to speech. The other option is for the user to copy and paste the web text into an online TTS engine. An example of this is www.Text2Speech.org. No mobile browser plugin for Firefox provided browser based TTS. The other option is to create a text file on the phone and then open the text file in say VoiceDream. The last resort is to revert to screen reading.

Econtent format:

1. Tap the PDF download URL.
2. Dialogue window complete action using:
 - a. Firefox Download
 - b. (Google) Drive PDF Viewer
 - c. eBook Reader

Appendix G: Framework development

- d. Download to Bluefire
3. Just Once/Always.

Ereader:

1. Navigate to Google Drive PDF Viewer and double tap to enter.
2. Navigate to the three dot menu and tap it once.
3. Navigate to and select 'Open with...' or 'Print' then tap.
4. Open with...

Select 'Voice Dream Reader' from the following list:

- a. eBook Reader
 - b. Lektz
 - c. Voice Dream Reader
 - d. Adobe acrobat
 - e. PDF Viewer
 - f. Foxit PDF
 - g. Download to Bluefire
 - h. Digital Editions
 - i. Gitden Reader or PDF Plugin for Gitden.
 - j. Amazon Kindle.
5. The PDF is imported into the library/etext shelf of Voice Dream.
 6. Scroll down/navigate to the PDF entitled "a26-Rogers".
 7. Single tap to open the PDF.

Econtent:

1. Single tap the play button to activate TTS. Press again to pause.
2. Double tap any line of text to be read out aloud.

G.1.7 Dyslexia (cognitive impairment) – margin, line and character spacing (visual stress)

Includes margin spacing, line spacing, character spacing. Other settings such as Justify text and flashing or blinking screen content will need to be tested in due course. Is justify text a core accessibility setting? Adjusting text colour, background colour and text type (font style) can be essential to those with visual processing difficulties (Web2Access). The PDF ecosystem prevents the altering of custom text colour and background colour. The only options are night mode with white text on a black background. Or in VoiceDREAM Dark, Light or Custom. Dark is White Text on a black background. Light is the reverse of this. The custom option is dealt with in Themes below.

Discovery:

1. Navigate to and open Firefox Mobile Browser.
2. Type in SUSSED using Bluetooth or on screen keyboard to enter the term SUSSED into the mobile browser.
3. Tap the SUSSED link.
4. Navigate to the username box.
5. Type in Username.
6. Navigate to the password box.
7. Type in Password.
8. Tap sign in button to sign in.
9. Navigate to Library tab and tap to enter.
10. Navigate to Resources link and tap to enter.
11. Navigate to A-Z List of e-Resources URL and tap to enter.
12. Navigate to ACM Digital Library and tap to enter.
13. Navigate to ACM DL search entry box tap to enter.

There are no settings currently available in the mobile Firefox Browser to alter settings that reduce visual stress, such as being able to alter margin spacing, line spacing or character spacing.

Search metadata:

1. Type in the text “Evaluating the mobile web accessibility of electronic text” either using the Bluetooth keyboard or the on screen keyboard.
2. Tap the search button.
3. Tap the papers URL.
4. The papers page provides the abstract to read prior to download.

Econtent format:

1. Tap the PDF download URL.

Appendix G: Framework development

2. Dialogue window complete action using:
 - a. Firefox Download
 - b. (Google) Drive PDF Viewer
 - c. eBook Reader
 - d. Download to Bluefire
3. Just Once/Always.

Ereader:

1. Navigate to Google Drive PDF Viewer and double tap to enter.
2. Navigate to the three dot menu and tap it once.
3. Navigate to and select 'Open with...' or 'Print' then tap.
4. Open with...
Select 'Voice Dream Reader' from the following list:
 - a. eBook Reader
 - b. Lektz
 - c. Voice Dream Reader
 - d. Adobe acrobat
 - e. PDF Viewer
 - f. Foxit PDF
 - g. Download to Bluefire
 - h. Digital Editions
 - i. Gitden Reader
 - j. Amazon Kindle
 - k. PDF Plugin for Gitden.
5. The PDF is imported into the library/etext shelf of Voice Dream.
6. Scroll down/navigate to the PDF entitled "a26-Rogers".
7. Single tap to open the PDF.
8. Navigate to the 'Aa' menu and single tap to open the menu.
9. In visual settings: set the Layout to Text Only.
10. Select All for Lines Visible.
11. Single tap Other Text Settings.
12. Adjust Character Spacing, Line Spacing and Side Margins as required.
13. Voice Dream reader does not allow the result to be resaved or printed.

Econtent:

1. The PDF text does alter character spacing, line spacing and side margins in reflow/text only layout. The text is extracted from the PDF using Foxit¹ technology.

¹ <https://www.foxitsoftware.com/>

G.1.8 Dyslexia (cognitive impairment) – read along

Using media overlays, this setting provides the user with the option of reading along with a moveable highlight bar as the text is read aloud through the TTS engine. The volume could be turned down if no TTS is required.

Discovery:

1. Navigate to and open Firefox Mobile Browser.
2. Type in SUSSED using Bluetooth or on screen keyboard to enter the term SUSSED into the mobile browser.
3. Tap the SUSSED link.
4. Navigate to the username box.
5. Type in Username.
6. Navigate to the password box.
7. Type in Password.
8. Tap sign in button to sign in.
9. Navigate to Library tab and tap to enter.
10. Navigate to Resources link and tap to enter.
11. Navigate to A-Z List of e-Resources URL and tap to enter.
12. Navigate to ACM Digital Library and tap to enter.
13. Navigate to ACM DL search entry box tap to enter.
14. There are no settings currently available in the Firefox mobile browser for Media Overlays or read along.

Search metadata:

1. Type in the text “Evaluating the mobile web accessibility of electronic text” either using the Bluetooth keyboard or the on screen keyboard.
2. Tap the search button.
3. Tap the papers URL.
4. The papers page provides the abstract to read prior to download.

Econtent format:

1. Tap the PDF download URL.
2. Dialogue window complete action using:
 - a. Firefox Download
 - b. (Google) Drive PDF Viewer
 - c. eBook Reader
 - d. Download to Bluefire
3. Just Once/Always.

Ereader:

1. Navigate to Google Drive PDF Viewer and double tap to enter.
2. Navigate to the three dot menu and tap it once.
3. Navigate to and select 'Open with...' or 'Print' then tap.
4. Open with...
Select 'Voice Dream Reader' from the following list:
 - a. eBook Reader
 - b. Lektz
 - c. Voice Dream Reader
 - d. Adobe acrobat
 - e. PDF Viewer
 - f. Foxit PDF
 - g. Download to Bluefire
 - h. Digital Editions
 - i. Gitden Reader
 - j. Amazon Kindle
 - k. PDF Plugin for Gitden.
5. The PDF is imported into the library/etext shelf of Voice Dream.
6. Scroll down/navigate to the PDF entitled "a26-Rogers".
7. Single tap to open the PDF.
8. Navigate to the 'Aa' menu and single tap to open the menu.
9. In visual settings: set the Layout to Text Only. Additional menu settings should appear.
10. Select All for Lines Visible.
11. Under 'Color' select Customize. Spoken Word colour, Spoken Line Colour and Highlight Colour can be altered as required. The Android version of VoiceDream is temperamental at the moment. Any crashes should be reported to VoiceDream.

Econtent:

1. The media overlay for VoiceDream does not currently work when in Layout Text Only (Reflow) mode.

2. When in PDF layout mode the media overlay and adjustments to Spoken Word Colour, Spoken Line Colour and Highlight Colour are recognised. There is also a restore Defaults button.

G.1.9 Dyslexia (cognitive impairment) – themes

This includes Font Style. Font Colour and Background colour can only be adjusted in ePub3 because Adobe currently charges for the use of changing background colour and text colour in Adobe Acrobat Standard for Desktop. Custom theme colours for spoken word, spoken line colour and highlight colour can be altered in VoiceDream. The Android version of VoiceDream is temperamental at the moment. Any crashes should be reported to VoiceDream. In addition to the Light/Dark themes referred to in the Visual Stress section there is also the Custom Theme option.

Discovery:

1. Navigate to and open Firefox Mobile Browser.
2. Type in SUSSED using Bluetooth or on screen keyboard to enter the term SUSSED into the mobile browser.
3. Tap the SUSSED link.
4. Navigate to the username box.
5. Type in Username.
6. Navigate to the password box
7. Type in Password.
8. Tap sign in button to sign in.
9. Navigate to Library tab and tap to enter.
10. Navigate to Resources link and tap to enter.
11. Navigate to A-Z List of e-Resources URL and tap to enter.
12. Navigate to ACM Digital Library and tap to enter.
13. Navigate to ACM DL search entry box tap to enter.

There are currently no mobile Firefox browser settings to create or alter custom themes, such as yellow text on a black background or to alter font style. There are third party Firefox addons, such as Lightweight Themes Switcher, that allow the browser to be themed. Third party addons can be problematic.

Search metadata:

1. Type in the text “Evaluating the mobile web accessibility of electronic text” either using the Bluetooth keyboard or the on screen keyboard.
2. Tap the search button.
3. Tap the papers URL.
4. The papers page provides the abstract to read prior to download.

Econtent format:

1. Tap the PDF download URL.
2. Dialogue window complete action using:
 - a. Firefox Download

- b. (Google) Drive PDF Viewer
 - c. eBook Reader
 - d. Download to Bluefire
3. Just Once/Always.

Ereader:

1. Navigate to Google Drive PDF Viewer and double tap to enter.
2. Navigate to the three dot menu and tap it once.
3. Navigate to and select 'Open with...' or 'Print' then tap.
4. Open with...
Select 'Voice Dream Reader' from the following list:
 - a. eBook Reader
 - b. Lektz
 - c. Voice Dream Reader
 - d. Adobe acrobat
 - e. PDF Viewer
 - f. Foxit PDF
 - g. Download to Bluefire
 - h. Digital Editions
 - i. Gitden Reader
 - j. Amazon Kindle
 - k. PDF Plugin for Gitden.
5. The PDF is imported into the library/etext shelf of Voice Dream.
6. Scroll down/navigate to the PDF entitled "a26-Rogers".
7. Single tap to open the PDF.
8. Navigate to the 'Aa' menu and single tap to open the menu.
9. In visual settings: set the Layout to Text Only. Additional menu settings should appear.
10. Under text appearance it is possible to alter the Font from a drop down list of 11 different type faces.
11. Custom themes are only available for ePub3.

Econtent:

1. When altering the font type/style the etext alters accordingly.
Adobe Acrobat Reader can be duped into providing yellow text on a black background. Simply have all the text in URL link blue. When you open it in Adobe Acrobat Reader it shows as yellow text.

G.1.10 Physical difficulties – switch access control

Using Switch Access On with Scanning Method Row-Column (keyboard only) selected.

Scanning highlight colour red with highlight line style set to thin solid line. Auto Scan disabled. The default assigned keys for scanning are Space for Select, '.' for next and ',' for previous. Automatically start scanning deselected.

Discovery:

1. Navigate to and open Firefox mobile browser using Scan.
2. Navigate to 'Search' or 'Enter Address' using scan (this would need to be done with Talkback on). Scan places focus at the top of the screen covering the entire browser address bar, history preview tab and the three dot menu. Select this using Space on the Bluetooth Keyboard and then select 'Select (2)' in the Scan menu. This provides access to the search bar so that text can be inputted.
3. Type in SUSSED using Bluetooth or on screen keyboard to enter the term SUSSED in the mobile browser.
4. The Firefox browser automatically places focus on the username field.
5. Type in Username using the Bluetooth keyboard. Use scan to select the return key on the on screen keyboard to move to the password field. First you select which row of keys you require then which key you require.
6. Type in Password using the Bluetooth keyboard. Use scan to select the return key on the on screen keyboard to move to the sign field. Pressing return goes straight to sign in or select sign in button to sign in using scan.
7. The scan function does not allow the user to navigate to the Library tab. Tap the library tab to enter the library portal.
8. The scan function does not allow the user to navigate to the Resources link. Tap to enter the resources link.
9. The scan function does not allow the user to navigate to the A-Z List of e-Resources URL. Tap to enter.
10. The scan function does not allow the user to navigate to ACM Digital Library. Tap to enter.
11. The scan function does not allow the user to navigate to ACM DL search entry box. Tap to enter.

Search metadata:

1. Type in the text "Evaluating the mobile web accessibility of electronic text" either using the Bluetooth keyboard or the on screen keyboard. Or using scan select a previous search entry from the ACM search box drop down menu.
2. The scan function does not allow the user to navigate to ACM DL search button. Tap the search button.
3. The scan function does not allow the user to navigate to the resulting paper URL. Tap the papers URL.

4. The papers page provides the abstract to read prior to download. The scan function does not allow the user to navigate to the PDF Download URL link or the preview abstract.

Econtent format:

1. Tap the PDF download URL.
2. Use the scan function in the dialogue window to complete action using option (b.) below:
 - a. Firefox Download
 - b. (Google) Drive PDF Viewer
 - c. eBook Reader
 - d. Download to Bluefire
3. Just Once/Always.
4. Press space bar on the Bluetooth keyboard to select.

Ereader:

1. Use the scan function to navigate to the three dot menu and press the space bar on the Bluetooth keyboard to select.
2. Use the scan function to navigate to and select 'Open with...' or 'Print' by pressing the space bar.
3. In Open with... use the scan function to navigate to 'Voice Dream Reader' from the following list and press the space bar for (c):
 - a. eBook Reader
 - b. Lektz
 - c. Voice Dream Reader
 - d. Adobe acrobat
 - e. PDF Viewer
 - f. Foxit PDF
 - g. Download to Bluefire
 - h. Digital Editions
 - i. Gitden Reader
 - j. Amazon Kindle
 - k. PDF Plugin for Gitden.
4. The PDF is imported into the library/etext shelf of Voice Dream.
5. Using the scan function navigate to the PDF entitled "a26-Rogers" and press the space bar twice to open it.
6. Use the scan function to navigate to the required settings in Voice Dream, such as TTS.

Econtent:

1. If TTS is selected through the scan function the PDF is read aloud.

If pause is selected using the scan function the TTS is paused.

Appendix H Ethics applications for the expert reviews

H.1 Expert Review One application

Reference number: ERGO/FPSE/18699	Version: 1.0	Date: 2016-01-07
Name of investigator(s) : Neil Rogers		
Name of supervisor(s) (if student investigator(s)): Mike Wald and E.A. Draffan		
Title of study: Pilot Survey - Beginning to establish functional accessibility categories for mobile: device, in-application and, if available, in-browser settings.		
Expected study start date: 14 th January 2016	Expected study end date: 14 th January 2016	

H.1.1 Pre-study

Characterise the proposed participants
Approximately 20 expert participants within the domain of alternative formats (altformats) will be from non-governmental organisations such as Load2Learn, JISC, the University of Kent and the University of Southampton. Abi James and E.A Draffan will be hosting the meeting with Ben Watson coming from Kent University and Alistair McNaught from JISC. Ben Watson is the organiser. Jennie Nunn – Wessex Needs Assessment Centre (WNAC) and Laura Palmour (WNAC) from the University of Southampton have also been invited but have not as yet confirmed attendance. Jonathan Richards, a disability contact at the Hartley Library, has also been invited. E.A. Draffan is the second supervisor to Neil Rogers – the survey originator. Neil Rogers also has a working relationship with Abi James and has met Ben Watson and Alistair McNaught on previous occasions.

Describe how **participants** will be approached

On the 14th January 2016 a face to face meeting about the use and development of alternative formats will be held in the Faculty Board Room of Building 32, Room 4073 at the University of Southampton, with around 20 experts in the field attending. During the meeting Neil Rogers will present information about his research survey for approximately five minutes and then give participants the opportunity to ask questions about the study. Lunch is included and the meeting will run from 9:30 am – 3:00 pm. No non-FPSE e-mail lists are to be used.

Describe how inclusion and/or exclusion criteria will be applied (if any)

Only the expert participants who read the distributed participant information and express informed verbal consent will be accepted as participants and allowed to undertake the survey. This will be undertaken in order to comply with the participant information and consent requirements below.

Describe how **participants** will decide whether to take part

Post presentation, participants will be given the opportunity to ask questions, they will then be asked if they would be willing to complete a short survey relating to the survey originators doctoral research. Following this, the hardcopy *participant information* (see Appendix i) will be distributed to all participants who express an interest. The participants will be given approximately five minutes to read the document. Once completed, only those participants who have read the document and provided informed verbal consent will then be accepted as participants and allowed to undertake the survey.

H.1.2 During the study

Describe the study procedures as they will be experienced by the **participant**

Step by step study procedures:

1. All experts attending the meeting will see a brief power point presentation of information about the survey, lasting approximately 5 minutes.
2. All experts will then be given an opportunity to ask questions about the survey, lasting approximately 5 minutes.
3. Those experts expressing an interest to take part in the study will be issued with a participant information sheet and asked to provide informed verbal consent.
4. Only the experts who read the participant information and express informed verbal consent will be accepted as participants and allowed to undertake the survey.

Post presentation and participant information, the wording for verbal consent will be as follows:

‘Do you give your informed consent to take part in this survey?’

Steps 3 and 4 should take no longer than approximately 5 minutes.

5. The participants will then be required to read and fill out the survey. This should take approximately 15 minutes. In total, approximately 30 minutes will be required for the combined presentation, participant information, verbal consent and survey time.

Justification for collecting information about gender:

Gender information needs to be collected during the survey in order to establish a sample population. Brajnik *et al*, accessibility experts, also gather information about gender for a similar expert study. <http://dx.doi.org/10.1080/07370024.2011.601670> Pg. 253.

6. Notably: at the end of the survey the participants are asked if they can help further by providing non identifiable screen shots of OS accessibility menus, and the Model/OS version if they have access to a Windows or Blackberry mobile device. The participant is then requested to place the anonymous screenshots into a Dropbox folder, accessed only by a unique private URL that will only be distributed at the end of the survey to accepted participants.

7. The participants will be asked not to provide OS screen shots that could personally identify them, and to make sure the short and long Dropbox URLs provided at the end of the survey are not disclosed to any third parties.

Steps: 6 and 7 can take place after the survey at the participant's convenience, however, the participants will be advised that a time limit of two weeks will be set and the Dropbox folder will be permanently removed at that point.

As the meeting was already pre-planned and organised by Ben Watson the time and travel expenses would fall to each individual who has already expressed an interest in attending the event. The survey originator will not be assisted or have collaboration, specific to the survey, from the hosts of the event, Abi James or E.A. Draffan.

Identify how, when, where, and what kind of data will be recorded (not just the formal research data, but including all other study data such as e-mail addresses and signed consent forms)

1. Formal research data: Pilot Survey – See Appendix (ii) for the survey itself:

The pilot hardcopy survey data will be manually gathered on the 14th January 2016 in the Faculty Board Room of Building 32, Room 4073 at the University of Southampton during an altformat meeting attended by 20 domain experts. Post survey, the pilot hardcopy data will be kept under lock and key in the survey originators desk in Building 32 Bay 13 3069. The hardcopy survey will be shredded post upgrade and no copies will be made. Hardcopy data analysis will take place prior to upgrade.

2. Anonymous mobile device accessibility OS Menu screenshots:

Post study the participants may be able to help further by providing anonymous accessibility OS menu screenshots of a Windows or Blackberry mobile device. The participants will be asked to place the anonymous screenshots into a predefined folder on Dropbox that can only be accessed with a URL that is indicated at the end of the survey. The participants will also be asked not to disclose the URL to any third parties. Furthermore, the Dropbox folder will only remain live for two weeks.

H.1.3 Post study

Identify how, when, and where data will be stored, processed, and destroyed

The anonymous screenshots, post study, referred to in step 6 of the previously mentioned step by step procedures, will need to be placed on Dropbox by the participant. This is currently the only means the survey originator has been able to find to achieve this. The location of the Dropbox folder is provided at the end of the survey, see Appendix (ii).

Other options, such as the University of Southamptons Drop Off were considered but unfortunately the service does not allow an anonymous file to be placed on the Universities Servers; whereas Dropbox does.

The anonymous screenshots will not be processed on Dropbox. Once all anonymous screenshots have been put on Dropbox they will be moved to \\pgsamba.ecs.soton.ac.uk a password protected secure University server maintained by IT professionals and then permanently deleted from Dropbox. Analysis or processing of the screenshots will only take place in a secure University approved environment.

H.1.4 Study characteristics

(L.1) The study is funded by a commercial organisation: No (delete or highlight one) If 'Yes', provide details of the funder or funding agency here
N/A

(L.2) There are restrictions upon the study: No (delete or highlight one) If 'Yes', explain the nature and necessity of the restrictions here
N/A

(L.3) Access to participants is through a third party: No (delete or highlight one) If 'Yes', provide evidence of your permission to contact them as a separate appendix. Do not provide explanation or information on this matter here

(M.1) Personal data is collected or processed: No (delete or highlight one) Data will be processed outside the UK: No (delete or highlight one) If 'Yes' to either question, provide the DPA Plan as a separate appendix. Do not provide information or explanation on this matter here. Note that using or retaining e-mail addresses, signed consent forms, or similar study-related personal data requires M.1 to be "Yes"

(M.2) There is inducement to participants : No (delete or highlight one) If 'Yes', explain the nature and necessity of the inducement here
N/A

(M.3) The study is intrusive: No (delete or highlight one) If 'Yes', provide the Risk Management Plan and the Debrief Plan as appendices, and explain here the nature and necessity of the intrusion(s)
N/A

(M.4) There is risk of harm during the study: No (delete or highlight one) If 'Yes', provide the Risk Management Plan, the Contact Information, and the Debrief Plan as appendices, and explain here the necessity of the risks
N/A

(M.5) The true purpose of the study will be hidden from participants: No (doho) The study involves deception of participants: No (delete or highlight one) If 'Yes' to either question, provide the Debrief Plan as an appendix, and explain here the necessity of the deception
N/A

(M.6) Participants may be minors or otherwise have diminished capacity: No (doho) If 'Yes', AND if one or more Study Characteristics in categories M or H applies, provide the Risk Management Plan and the Contact Information, as appendices, and explain here the special arrangements that will be put in place that will ensure informed consent
N/A

(M.7) Sensitive data is collected or processed: No (delete or highlight one) If 'Yes', provide the DPA Plan as a separate appendix. Do not provide explanation or information on this matter here

Appendix H: Ethics applications for the expert reviews

(H.1) The study involves: **invasive** equipment, material(s), or process(es); or **participants** who are not able to withdraw at any time and for any reason; or animals; or human tissue; or biological samples: **No** (delete or highlight one)

If 'Yes', provide further details and justifications as one or more separate appendices. Do not provide explanation or information on these matters here. Note that the study will require separate approval by the Research Governance Office

H.1.5 Participant information

Ethics reference number: ERGO/FPSE/18699	Version: 1.0	Date: 2016-01-07
Study Title: Pilot Survey - Beginning to establish functional accessibility categories for mobile: device, in-application and, if available, in-browser settings.		
Investigator: Neil Rogers		

Please read this information carefully before deciding to take part in this research. If you are happy to participate you may be asked to sign a consent form. Your participation is completely voluntary.

What is the research about? This is a doctoral research survey which aims to begin to establish the functional categories for device, in-application and, if available, in-browser accessibility settings on mobile platforms; the principles behind the categories; and the relevant combinations of those settings to overcome the barriers experienced by mobile device users with print impairments when searching for and reading electronic texts in Higher Education.

The study is not funded by a third party commercial organisation.

Why have I been chosen? You have been approached because you are experts or stakeholders in the alternative format domain.

What will happen to me if I take part? You will have already seen a short presentation about this study and if you provide verbal consent you will then be asked to fill out a short survey. It will take about 15 minutes of your time.

Are there any benefits in my taking part? The study will add to current knowledge about Mobile Web Accessibility in Higher Education.

Are there any risks involved? There are no particular risks associated with your participation.

Will my data be confidential? All data collected is anonymous, your hardcopy survey data and screenshots will be held on a secure University server or under lock and key, and used only **in accordance with the Data Protection Act (1998)**.

What happens if I change my mind? You may withdraw at any time and for any reason during the survey. Once, however, the anonymous hard copy data is collected it is not possible for the participant to request its removal.

What happens if something goes wrong? Should you have any concern or complaint, contact me if possible (investigator e-mail: nrer1g14@soton.ac.uk), otherwise please contact the FPSE Office (e-mail: fpse-student@southampton.ac.uk) or any other authoritative body such as Dr Martina Prude, Head of Research Governance (02380 595058, mad4@soton.ac.uk).

H.1.6 Pilot survey

Ethics reference number: ERGO/FPSE/18699	Version: 1.0	Date: 2016-01-07
Study Title: Pilot Survey - Beginning to establish functional accessibility categories for mobile: device, in-application and, if available, in-browser settings.		
Investigator: Neil Rogers		

Aim: The aim of this pilot survey is to begin to establish the functional categories for device, in-application and, if available, in-browser accessibility settings on mobile platforms; the principles behind the categories; and the relevant combinations of those settings to overcome the barriers experienced by mobile device users with print impairments when searching for and reading electronic texts in Higher Education.

INSTRUCTIONS:

Please do not confer with other colleagues while answering this survey. If you would like to talk about the survey after it has been completed, please feel free to do so. This survey follows on from the brief presentation just given and should take no more than 15 minutes of your time to complete.

This open ended survey has been deliberately designed to allow you to bring new ideas, further avenues of exploration or constructive criticism to the fore, particularly in light of your experience and expert knowledge.

Queries or Issues? : If you feel this survey will not provide the relevant data, please do comment on this in the answers you provide with possible suggestions to overcome this. Furthermore, if any part of this survey does not make sense please feel free to speak to the survey originator – namely, Neil Rogers.

H.1.7 Survey questions

Please answer the following questions without conferring with your colleagues. If you require additional space for answers, please use the 'Further Comments' page at the end of this survey. Please place a tick '✓' in the required box '☐'.

1. Demographics and expertise:

What is your gender? M ☐ F ☐ Other ☐ (Please specify: _____)

Prefer not to say ☐

What is your age range?

18-29 ☐ 30-49 ☐ 50-64 ☐ 65+ ☐ Prefer not to say ☐

Subjective Knowledge Rating:

On a scale of 1 to 5 what is the level of your domain knowledge or expertise?

1 = lowest and 5 = highest: 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

Worked as a consultant/specialist/librarian for:

Less than two years ☐ 2-5 years ☐ 6-10 years ☐ 11-15 years ☐ 16+ years ☐

Tested more than 10 web sites for accessibility? Yes ☐ No ☐

Tested mobile applications/browsers for accessibility? Yes ☐ No ☐

Tested mobile devices for accessibility? Yes ☐ No ☐

Do you use an eReader for reading academic etexts? Yes ☐ No ☐

2. Functional categories for accessibility settings:

Based on human cognition and the human senses what functional categories for device, application and browser accessibility settings should there be on a smart-phone or tablet?

3. Principles behind the categories:

What principles should govern the functional categories?

4. Relevant combinations of settings to overcome barriers to eReading:

What combinations of eReader settings should be provided to overcome barriers?

- 5. Framework Elements:** The following are a set of six framework element examples with suggested direct relevance to Higher Education ereading for users with print impairments, taken from the exploration of over 500 device settings and 40 mappings.

Table 1: Example framework element set

Settings	Algorithm Fit	User Input/ Output	Element (Direct relevance to HE eReading for users with print impairments)
Display	Device OS	Output	Display resolution affects touch accuracy
Large Text	Device OS Navigation	Input	Adjusting menu font size aids Visual Impairment
VPN	Discovery & eContent Format	Input/Output	Required to access online institute platform & downloading HTML/ePub, PDF when using 4G
< ONIX settings? >	Metadata	Output	A11y prior to purchase
Shake to start continuous reading	eReader	Input	< Would a user with mobility issues struggle with this? >
Gestures: Flick	eContent	Input	Move focus in app/browser

- How can the element importance/relevance/priority in **Error! Reference source not found.** be measured?
(eg. Task Ease or Difficulty/Task Time/Task Duration/Frequency of Barrier etc.)

You may be able to help further:



Do you have access to your own current Windows or Blackberry smartphone?

- Would you be willing to take screen shots of the accessibility and the about phone* menu settings on your device, and put them in the following folder on Dropbox? No information that could identify who you are should be put in the Dropbox folder. You don't necessarily have to do this now, just take a picture on your smartphone/tablet or make a note of this survey section. Short URL: <https://goo.gl/rzeDmN> Long URL (in case the short URL does not work): <https://www.dropbox.com/sh/f7pa98nlf6jtk5x/AAATMOFcUpJyvMSAKSyKwCpGa?dl=0> Please do not disclose these URL's to any third parties. The URL's will only be available for two weeks after today.

** Please note: only the Model and OS version of the Windows or Blackberry device are needed from the 'about phone' menus.*

Thank you for your time and help in filling out this survey.

Further comments:

H.1.8 Verbal consent wording

Ethics reference number: ERGO/FPSE/18699	Version: 1.0	Date: 2016-01-07
Study Title: Pilot Survey - Beginning to establish functional accessibility categories for mobile: device, in-application and, if available, in-browser settings.		
Investigator: Neil Rogers		

Verbal Consent Wording: Post presentation and following the distribution of participant information, the wording for verbal consent will be as follows:

‘Do you give your informed consent to take part in this survey?’

The full datasets for the Expert Review One results can be found in: N.E. (2019) Dataset for: Automatically evaluating the mobile web accessibility of Higher Education electronic texts for print impairments. University of Southampton doi: 10.5258/SOTON/D1064 [Dataset] under ‘ExpertReview1SurveyResults.xlsx’. This includes the survey data, the thematic analysis and expert agreement.

The mapping between the comments made by the individual participants in Expert Review One and the published research findings can be found in: N.E. (2019) Dataset for: Automatically evaluating the mobile web accessibility of Higher Education electronic texts for print impairments. University of Southampton doi: 10.5258/SOTON/D1064 [Dataset] under ‘ExpertReview1BackgroundMapping.xlsx’.

H.2 Expert Review Two application

It should be noted that although this ethics application refers to an expert review 'validation', the word 'validation' was subsequently removed from the main thesis. The reason for this was that the results were adversely affected during the review because certain critical questions were unanswered, even though wording was provided to explain their importance to the individual experts who participated in the study.

Reference number: ERGO/FPSE/30291	Submission version: 2	Date: 2017-09-07
Name of investigator(s) : Neil Rogers		
Name of supervisor(s) (if student investigator(s)): Professor Mike Wald & E.A. Draffan		
Title of study: Expert Review Validation: Evaluating the mobile web accessibility of Higher Education electronic text for print impairments		
Expected study start date: 11 th September 2017 (or the first working day after ethics approval).	Expected study end date: 23 rd September 2017	

H.2.1 Pre-study

Characterise the proposed **participants**

16 expert participants, 8 male and 8 female, will be invited to participate from relevant domains, namely: those working as accessibility or alternative format (altformat) consultants; specialists; developers; librarians; and publishers. The participants will be from the following:

Higher Educational Institutes (HEI's):

1. Birkbeck – University of London;	6. Leeds Beckett University;
2. Bodleian Libraries;	7. Swansea University;
3. Johannes Kepler University;	8. University of Southampton
4. Kent University;	9. University of West England – Bristol; and
5. Kings College London;	10. York St John/Sheffield University

Publishers:

1. IoP Publishing
2. SAGE publishing

Digital Solutions Provider for UK education and research:

1. JISC

Neil Rogers has a working relationship with 8 of the participants.

Describe how **participants** will be approached

The link to the expert review validation on iSurvey will be sent in separate emails to 16 participants on the 11th September 2017, or the first working day after ethics approval. The survey questions will not be sent out with the email. The expert email addresses were obtained from a JISC list, except for IoP Publishing. The JISC list relates to the accessibility of altformats and is specific to HE etexts. IoP Publishing have provided written consent to take part in this survey. Using iSurvey, the participants will be able to respond to the review anonymously. No contact will be made with the experts once they have completed the survey, other than the iSurvey automated response that the survey has been completed. The anonymised results of the review and additional information for publishers and librarians will be made available at <https://expertreviewvalidation.wordpress.com/> provided at the end of the review. This URL will only be made available within iSurvey. The results will be made available after the 23rd September 2017. The additional information relates to mobile ereader applications that consider accessibility. This will help serve as an incentive for participants to respond.

Describe how inclusion and/or exclusion criteria will be applied (if any)

Participant and consent information will be provided on the landing page of iSurvey. Participants will be able to (print off and) take away (or store) an accessible copy. The following wording will be available in the participant information, 'Simply read the participant and consent information then place a tick (check) in the iSurvey box, prior to undertaking the review. This will indicate that you have read and agree to both the participant and consent information. Please then select 'Start the survey'. There is no time limit for doing this. If the participant does not place a tick (check) in the iSurvey box they will be prevented from proceeding.

Describe how **participants** will decide whether to take part

Once the expert has placed a tick in the relevant box they will be able to decide whether to take part in the review by selecting 'Start this survey' and proceeding. Again there is no time limit for doing this.

H.2.2 During the study

Describe the study procedures as they will be experienced by the **participant**

1. The expert participants will receive separate emails with the following content:
 - An invitation and link to the expert review validation on iSurvey.
 - Wording that if they select the link the participant will be taken to a landing page on iSurvey where they will be required to read the participant and consent information.
 - Wording stating that the anonymised results of the review and additional information for publishers and librarians will be made available at a URL provided at the end of the review in iSurvey. This will be made available after the 23rd September 2017.

The email should take the participant no longer than two minutes to read.

2. The link will take participants to the iSurvey landing page where the following information will be provided as accessible Word documents that can be downloaded:

- Participant Information;
- Consent Information.

Both the participant and consent information are provided in an accessible format (this is in compliance with the Equality Act 2010).

3. Once the expert participants have read this information they will then be required to give their implied consent by placing a tick (check) in a box on iSurvey, prior to undertaking the review, and then selecting 'Start this survey'.

4. The expert participants will then be required to:

- Read an overview page explaining the iSurvey sections;
- Answer questions relating to demographics and expertise;
- For a more in depth understanding, the key issues for mobile web accessibility are made available as an accessible Word document that can be downloaded if the expert requires them;
- Read the automatic checks and user tasks. For a more in depth understanding, the automatic checks are made available as an accessible Word document that can be downloaded if the expert requires them;
- Based on the use of a prototype to answer questions relating to the accessibility of an institute portal or publishers website. The survey will take approximately 15 - 20 minutes. If required, iSurvey allows the participant to save responses and to return when convenient. iSurvey automatically generates a username and password for the next visit to the review. The survey has two sections. All questions will be marked on iSurvey as compulsory, except for two questions that the librarians and publishers need to answer separately. These are questions seven and nine in section two of the survey. The reason for compulsory questions is that if they are not answered there will be a detrimental impact on the statistical analysis post survey. Unfortunately it is not possible to mark questions seven and nine as compulsory, but wording stating that they require an answer is indicated in the review.

5. iSurvey will then indicate when the review has been completed.

6. iSurvey provides an automatic message thanking the participants for taking part in the expert review whereupon the URL mentioned in 1 will be provided.

7. No travel expenses will be incurred by the participants and Neil Rogers will not be assisted or have collaboration from external parties.

Justification for collecting information about gender:

Gender information needs to be collected during this survey in order to establish a sample population. Brajnik *et al* [1], accessibility experts, also gather information about gender for a similar expert study to determine a sample population. [1] Giorgio Brajnik , Yeliz Yesilada & Simon Harper (2011) The Expertise Effect on Web Accessibility Evaluation Methods, Human–Computer Interaction, 26:3, 246-283 (see page 253).

Identify how, when, where, and what kind of data will be recorded (not just the formal research data, but including all other study data such as e-mail addresses and signed consent forms)

1. Formal research data:

The link to the expert review validation on iSurvey, and not the survey itself, will be sent in separate emails to 16 participants on the 11th September 2017, or the first working day after ethics approval. The participants will then be given one week to respond anonymously through iSurvey from the date they receive the link. Data collection will cease on the 23th September 2017 at 11:59pm. The expert review will contain information to be read, questions to be answered and simple checks of an institute portal or publishers website based on the use of an online prototype.

2. No signed consent forms will be required because iSurvey will be used.

H.2.3 Post study

Identify how, when, and where data will be stored, processed, and destroyed

iSurvey will store all data received on a password protected secure University server maintained by IT professionals. Processing and analysis of the data will only take place in a secure University approved environment. On completion of the doctorate the university retains the right to permanently delete the expert review held on iSurvey as and when it deems necessary. The survey results will only be made available until the end of the doctorate.

H.2.4 Study characteristics

(L.1) The study is funded by a commercial organisation: No (delete one) If 'Yes', provide details of the funder or funding agency <i>here</i>.

(L.2) There are restrictions upon the study: No (delete one) If 'Yes', explain the nature and necessity of the restrictions <i>here</i>.

(L.3) Access to participants is through a third party: No (delete one) If 'Yes', provide evidence of your permission to contact them as Appendix (v). Do <i>not</i> provide explanation or information on this matter <i>here</i>.

(M.1) Personal data is or *may be collected or processed: Yes (delete one) Data will be processed outside the UK: No (delete one) If 'Yes' to either question, provide the DPA Plan as Appendix (iv). Do <i>not</i> provide information or explanation on this matter <i>here</i>. Note that using or recording e-mail addresses, telephone numbers, signed consent forms, or similar study-related personal data requires M.1 to be "Yes". (* Secondary data / "big data" may be <i>de</i>-anonymised, or may contain personal data. If so, answer 'Yes'.)

(M.2) There is inducement to participants: No (delete one) If 'Yes', explain the nature and necessity of the inducement <i>here</i>.

Appendix H: Ethics applications for the expert reviews

(M.3) The study is **intrusive**: **No** (delete one)

If 'Yes', provide the **Risk Management Plan**, the **Debrief Plan**, and Technical Details as Appendices (vi), (vii), and (ix), and explain *here* the nature and necessity of the intrusion(s).

(M.4) There is **risk of harm** during the study: **No** (delete one)

If 'Yes', provide the **Risk Management Plan**, the **Contact Information**, the **Debrief Plan**, and Technical Details as Appendices (vi), (vii), (viii), and (ix), and explain *here* the necessity of the risks.

(M.5) The true purpose of the study will be hidden from **participants**: **No** (delete one)

The study involves **deception** of **participants**: **No** (delete one)

If 'Yes' to either question, provide the **Debrief Plan** and Technical Details as Appendices (vii) and (ix), and explain *here* the necessity of the deception.

(M.6) **Participants** may be minors or otherwise have **diminished capacity**: **No** (delete one)

If 'Yes', AND if one or more Study Characteristics in categories M or H applies, provide the **Risk Management Plan**, the **Contact Information**, and Technical Details as Appendices (vi), (vii), & (ix), and explain *here* the special arrangements that will ensure informed consent.

(M.7) **Sensitive data** is collected or processed: **No** (delete one)

If 'Yes', provide the **DPA Plan** and Technical Details as Appendices (iv) and (ix). Do *not* provide explanation or information on this matter here.

(H.1) The study involves: **invasive** equipment, material(s), or process(es); or **participants** who are not able to withdraw at any time and for any reason; or animals; or human tissue; or biological samples: **No** (delete one)

If 'Yes', provide Technical Details and further justifications as Appendices (ix) and (x). Do *not* provide explanation or information on these matters here. Note that the study will require separate approval by the Research Governance Office.

H.2.5 iSurvey: expert review validation

Ethics reference number: ERGO/FPSE/30291	Version: 2	Date: 2017-09-07
Title of study: Expert Review Validation: Evaluating the mobile web accessibility of Higher Education electronic text for print impairments		
Investigator: Neil Rogers		



Expert Review Validation

To increase type size in your browser please press 'CTRL' and '+' on a Windows PC or '⌘' and '+' on a MAC.

Please help us: to learn more about evaluating the mobile web accessibility of Higher Education electronic text for print impairments. This survey will be anonymous.

Prior to undertaking the survey, you will need to read the participant and consent information. This information is available as accessible Word documents and can be downloaded at the following URLs:

1. Participant Information (<https://goo.gl/ykgYQu>)
2. Consent Information (<https://goo.gl/xEshGz>)

 A password is required to access this survey. Please enter password below

☐ Please tick (check) this box to indicate that you have read and agree to both the participant and consent information.

Start this survey 

H.2.6 Participant Information

Ethics reference number: ERGO/FPSE/30291	Version: 2	Date: 2017-09-07
Title of study: Expert Review Validation: Evaluating the mobile web accessibility of Higher Education electronic text for print impairments		
Investigator: Neil Rogers		

The following participant information will be available as an accessible Word document at <https://goo.gl/ykgYQu>

Study Title: Expert Review Validation: Evaluating the mobile web accessibility of Higher Education electronic for print impairments

Researcher: Neil Rogers

ERGO number: ERGO/FPSE/30291

Please read this information carefully before deciding to take part in this research. It is up to you to decide whether or not to take part. If you are happy to participate you will be asked, prior to undertaking the review, to read and agree to participant and consent information on iSurvey, the University of Southampton's official data gathering tool. Your participation is completely voluntary.

What is the research about?

This is a doctoral research project being undertaken at the University of Southampton that aims to determine the feasibility of an automated accessibility evaluation tool. You will also be encouraged to offer your expert opinions about what you read and the checks undertaken.

Why have I been asked to participate?

You have been approached because you are experts in relevant domains that relate to the mobile web accessibility of electronic text in Higher Education (HE).

What will happen to me if I take part?

You will be required to read information and answer short questions relating to:

- Demographics and expertise. Demographics data (eg. your gender or age) is required to establish a sample population.
- The accessibility of your Institute portal or publishers website based on the use of a prototype tool. We recommend using a desktop/laptop to run the prototype because the initial download of the prototype is slow on mobile devices or a low bandwidth internet connection.

Are there any benefits in my taking part?

The study will add to current knowledge about mobile web accessibility of electronic text in HE and will provide you with the opportunity to use the first iteration of a prototype tool that meets key mobile web accessibility requirements.

Are there any risks involved?

There are no risks associated with your participation.

Will my participation be confidential?

All data collected is anonymous and will be held on a password protected secure University server, and used only in accordance with the Data Protection Act (1998). Please note: that once your data is collected it is not possible for you to request its removal.

What should I do if I want to take part?

Simply read the participant and consent information then place a tick (check) in the iSurvey box, prior to undertaking the review. This will indicate that you have read and agree to both the participant and consent information. Please then select 'Start the survey'.

What happens if I change my mind?

You may withdraw at any time and for any reason.

What will happen to the results of the research?

Anonymised results of the survey and additional information for publishers and librarians will be made available at (<https://expertreviewvalidation.wordpress.com/>), this will be made available after the 23rd September 2017.

Where can I get more information?

If required, please contact Neil Rogers (nrer1g14@soton.ac.uk).

What happens if something goes wrong?

In the unlikely event of concern or complaint, you should contact the Research Integrity and Governance Manager (023 8059 5058, rgoinfo@soton.ac.uk).

Thank you.

Thank you for taking the time to read this information and considering taking part in this research.

H.2.7 Email information for iSurvey link

Ethics reference number: ERGO/FPSE/30291	Version: 2	Date: 2017-09-07
Title of study: Expert Review Validation: Evaluating the mobile web accessibility of Higher Education electronic text for print impairments		
Investigator: Neil Rogers		

Ethics reference number: **ERGO/FPSE/30291**

Dear <Name>,

If the named participant is known to Neil Rogers the email will be prefaced with a brief personal comment followed by the invitation below.

If the named participant is not personally known to Neil Rogers the following invitation will be used.

You are invited to take part in an expert review validation because you are an expert in a relevant domain that relates to the mobile web accessibility of electronic text in Higher Education (HE).

Appendix H: Ethics applications for the expert reviews

The following link:

<https://www.isurvey.soton.ac.uk/24151>

will take you to a landing page on iSurvey, the University of Southampton's official data gathering tool, where you will need to read the participant information and consent information provided before proceeding.

The password on iSurvey is: erv2017

The survey itself will take no longer than 15 - 20 minutes of your time. iSurvey allows you to save responses and return when convenient by automatically generating a new username and password.

The results of the review and additional information for publishers and librarians will be made available after the 23rd September 2017 at a URL provided at the end of the survey. The survey will close on the 23rd September 2017 at 11:59 pm. If, however, you can provide responses before then that would be helpful. The additional information relates to 13 native and online ereader applications that consider accessibility. It is hoped that this information will save you a great deal of time.

Yours sincerely,

Neil Rogers

University of Southampton

Electronics and Computer Science,

Web and Internet Science Group, Building 32

<http://www.ecs.soton.ac.uk/people/nrer1g14>

H.2.8 Email consent from the publisher IoP re the Expert Review

Ethics reference number: ERGO/FPSE/30291	Version: 2	Date: 2017-09-07
Title of study: Expert Review Validation: Evaluating the mobile web accessibility of Higher Education electronic text for print impairments		
Investigator: Neil Rogers		



Mon 06/06/2016 13:41

Re: Accessible ePub3 and ONIX Accessibility Metadata

To: Rogers N.R.E.

Cc:

Thanks Neil

I know the book and have it in my system - but I must admit I've not looked at it since I downloaded it years ago,. I'll revisit it now and pass on copies to the relevant people here.

No problem with the survey, happy to help

H.2.9 iSurvey participant questionnaire, online walkthrough and prototype

Ethics reference number: ERGO/FPSE/30291	Version: 2	Date: 2017-09-07
Title of study: Expert Review Validation: Evaluating the mobile web accessibility of Higher Education electronic text for print impairments		
Investigator: Neil Rogers		

 Accessibility toolbar 

Expert Review Validation 

Overview

We recommend: using either a desktop with two screens or a laptop with an additional monitor connected and a printer to undertake this survey. In a separate browser window, please also start the prototype download available at <https://invis.io/7VD7CGCTR> so that it is downloading while you undertake the survey. This can be done by pressing 'CTRL' and selecting the link.

You can return to the survey at any point by selecting 'Save and Quit' top right.

This survey has questions in two sections:

- Section 1:** Demographics and expertise
- Section 2:** Automated checks and user tasks

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Expert Review Validation

Save and Quit

Section 1

Please answer the following demographics and expertise questions, every question requires an answer.

Question 1.

Demographics:

Please select your gender

Please select ▼

Question 2.

What is your age range?

18-29	30-49	50-64	65+	Prefer not to say
☐	☐	☐	☐	☐

Question 3.

Expertise:

Subjective Knowledge Rating: .

On a scale of 1 to 5

	Lowest	1	2	3	4	5	Highest
What is the level of your web accessibility knowledge? (eg. web content and the barriers faced by disabled people using the web.)		☐	☐	☐	☐	☐	
What is the level of your mobile web accessibility knowledge? (eg. small screen content & responsive design.)		☐	☐	☐	☐	☐	
What is the level of your mobile accessibility knowledge? (eg. device hardware and accessibility settings.)		☐	☐	☐	☐	☐	

Appendix H: Ethics applications for the expert reviews

Question 4.

Working as an accessibility: consultant, specialist, developer, librarian, publisher:

Less than two

years

2-5 years

6-10 years

11-15 years

16+ years

☐☐☐☐☐

Question 5.

Tested more than 10 websites for accessibility in the last 6 months?

☐ Yes

☐ No

Question 6.

Tested more than 10 mobile applications for accessibility in the last 6 months?

☐ Yes

☐ No

Question 7.

Tested more than 3 mobile browsers for accessibility in the last 6 months?

☐ Yes

☐ No

Question 8.

Tested both the Android and iPhone mobile devices for accessibility in the last 6 months?

☐ Yes

☐ No

Question 9.

Have you used an ereader 'app' for reading academic electronic texts (etexts) on a smartphone in the last 6 months?

☐ Yes

☐ No

Question 10.

If yes, which format do you most regularly use?

☐ PDF

☐ ePub3

☐ Both the same

Question 11.

If PDF, and if available, do you use reflow?

☐ Yes

☐ No

Question 12.

Do you use Text to Speech (TTS)?

☐ Yes

☐ No

Survey Progress

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Save and Continue





Expert Review Validation



Section 2

This section identifies key issues for mobile web accessibility and provides you with a list of checks that will help you evaluate your Institute library portal or publishers website based on the use of a prototype tool. WCAG 2.0 is the predominant set of guidelines for mobile web accessibility and used throughout this review.

Please note: only smartphones are assessed in this survey and the participants will not be expected to know all the aspects of the mobile web accessibility domain. If required, for a more in depth understanding of the key issues for mobile web accessibility please refer to the accessible Word document available at (<https://goo.gl/FMWNEU>).

1. List of automated checks for device, mobile browser, and website

Visual Controls

1. High contrast can be altered.
2. Text and background colour or themes can be altered.
3. Margin width, line spacing, character spacing and full screen can be altered.
4. Text size, font typeface, left justify, text reflow and zoom/magnification can be altered.

Touch Controls

1. Check that the use of portrait or landscape mode can be altered.
2. Check that screen reader focus can be moved through navigation elements.

Audible Controls

1. Check that Text to Speech (TTS) and speech rate can be altered.

Speech Controls

1. Check that speech recognition can be altered in search boxes and the mobile browser address bar.

For a more in depth version of the automated checks please refer to the following made available as an accessible Word document at (<https://goo.gl/cQJLnY>).

Each of these automated checks needs to be undertaken for each of the following user tasks.

The following key issues for mobile web accessibility will be available as an accessible Word document at: <https://goo.gl/FMWNEU>

Ethics reference number: **ERGO/FPSE/30291**

Key issues for mobile web accessibility

1. The mobile accessibility guidelines provided by the BBC state three principles that highlight key issues that could be caused if best practice is not adhered to, namely:
 - 1.1. **Principle 1: Use platform and web standards as intended**
'When standards and guidelines are implemented using non-standard techniques there is a risk that users who are dependant on platform specific accessibility features such as accessibility settings and screen readers will be excluded from accessing [mobile web] content.'
 - 1.2. **Principle 2: Use standard User Interface (UI) controls where possible**
Standard UI controls are recognised by the OS screen reader and therefore by users.
 - 1.3. **Principle 3: Support platform accessibility**
'All content and functionality must work alongside, and not suppress, native accessibility, features and settings.'

Navigation methods: all content must be accessible and navigable using the platforms navigation paradigm for assistive technology.

Support platform assistive technologies or features: when applications or sites block, disable, or interfere with platform specific accessibility features or technology, disabled users may not be able to use the site or app. Other issues include suppressing zoom on websites or disabling the ability to highlight and copy text in HTML and therefore [TTS] features.'

This information can be found at:

([Key issues for mobile web accessibility](#))

Appendix H: Ethics applications for the expert reviews

The following in depth automated checks will be available as an accessible Word document at: <https://goo.gl/cQJLnY>

Ethics reference number: **ERGO/FPSE/30291**

Please read the two lists below in order to answer whether the automated checks below cover the user tasks in the mobile web browser, the institute library portal and on the publisher's website. *Please note:* checklist one is based on multiple standards and guideline success criteria, such as WCAG 2.0 relevant techniques and mobile accessibility, UAAG 2.0, EN 301549 and ETSI EG 203350.

1. List of automated checks for device, mobile browser and website

1. Visual Controls	1.1. Check high contrast is available and can be altered. Screen brightness and colour correction can affect this. (EN: SC 4.2.2, 4.2.3), (ETSI: SC 7.8.5, 12.3.1), (WCAG 2.0 SC 1.4.1).
	1.2 Check that text and background colour or customisable themes can be altered. This should also include the provision of colour overlays (altering foreground colour). (WCAG 2.0 SC 1.4.8), (UAAG 2.0 SC 1.4.2).
	1.3 Check that text size, font typeface, left justify, text reflow and zoom/magnification can be altered. This includes responsive websites. (WCAG 2.0: SC 1.4.4, 1.4.8), (UAAG 2.0 SC 1.4.2, 1.8.5, 1.8.8)
	1.4 Check margin width, line spacing, character spacing and full screen can be altered. (WCAG 2.0: SC 1.4.8), (UAAG 2.0 SC 1.8.8)

2. Touch Controls	2.1 Check that the use of portrait or landscape mode is available. (WCAG 2.0 Mobile SC 4.1) 2.2 Check that focus can be moved through navigation elements such as: controls, headings, labels, regions/landmarks, links using the OS screen reader. Links can include skip to main content, skip navigation or download a format. If the device gestures are accessible then hardware such as a Bluetooth keyboard, switch or braille display will also be accessible. Users should not be caught in the equivalent of a no keyboard trap for device gestures. Touch target size is also important here. (EN: SC 4.2.1, SC 4.2.2, SC 4.2.7, SC 4.2.8), (ETSI: SC 12.2.4) (WCAG 2.0 SC 1.3.1, SC 2.1.1, 2.1.2, 2.4.3, 2.4.4, 2.4.6, 2.4.7, 3.2.3, 3.2.4, 3.3.2, SCR20, C27), (UAAG 2.0 SC 1.3.1, 1.8.2, 2.1.1, 2.1.2, 2.1.4), (WCAG 2.0 Mobile SC 3.2), (UAAG SC 1.3.1, 2.1.1, 2.1.2, 2.11.1)
3. Audible Controls	3.1 Check Text to Speech (TTS) is available and can be altered. There is a pending Android API available for this. The TTS or the devices screen reader would need to read aloud image alt text. (EN: SC 4.2.2) (WCAG 2.0 SC 1.3.1, 3.1.1, H57), (UAAG 2.0 SC 1.6.1 to 1.6.5)
4. Speech Controls	4.1 Check speech recognition is available and can be altered in search boxes and the URL address bar. (WCAG 2.0 SC 4.1.2, ARIA16, G108, G135, G10)

Each of these automated checks need to be undertaken for each of the discovery and download user tasks.

2. List of user tasks for Discovery & Download

1. Search 1 and search 1 result(s)	Discovery: Search for and navigate to institute learning platform (Google search box & Google result links).
2. Institute authentication	Using a single sign in (such as Shibboleth or Athens) login to the institute library with username, password, and sign in button.
3. Institute library portal steps	Navigate through the library resources to the educational publishers website.
4. Search 2 and search 2 result(s)	Through single sign in to search for and navigate to the journal paper preview link on the publishers website. Publishers need to ensure that the user is taken directly to the paper searched for and not a general journal page.
5. Preview paper abstract	Read preview paper abstract made available on the educational publishers website.
6. Read accessibility metadata prior to download	Currently not available on vendors websites. The prototype provides a demonstration of this feature.
7. Search 2 result	Download: Select the download link for journal paper on educational the publishers website.
8. Manage downloads	Navigate through website options for local device download or transfer to third party cloud storage.

You will see these checks as you go through the prototype.

Please print out: The automated checks available at (<https://goo.gl/Y7hQkm>) and the user tasks available at (<https://goo.gl/EFDmYh>). These are accessible Word documents. The printouts will help you when you check your own library portal or publishers website.

Walkthrough and Prototype: The walkthrough and prototype, available at <https://invis.io/7VD7CGCTR>, should have downloaded by now. It has been designed to give, you the expert, an overview of a process undertaken by the academic or student for discovery and download of HE etexts.

Please note: You can enlarge the Invison prototype on a laptop/desktop by using CTRL '+' on a Windows machine or Apple '+' on a Mac. The prototype is not screen reader accessible and where speech is used this is mentioned on screen. Also please ignore the message 'Turn on comment mode to collaborate on this prototype' when you open the Invison prototype.

Please follow the on screen instructions for the prototype.

H.2.10 Survey questions

Question 1. Questions: Important: If you are a publisher please answer question nine. If you are a librarian please answer question seven. It is also important to answer the remaining questions. The following questions need to be answered with three perspectives in mind, namely: as the academic or student, the librarian, and the publisher. Based on the list of automated checks for user tasks (discovery and download) and the prototype tool: Can anything be improved? ☐ Yes ☐ No ☐ Not sure
Question 2. Please briefly explain your answer:
Question 3. Can anything be removed? ☐ Yes ☐ No ☐ Not sure
Question 4. Please briefly explain your answer:
Question 5. Has anything been overlooked? ☐ Yes ☐ No ☐ Not sure
Question 6. Please briefly explain your answer:

Question 7.

If you are a librarian it is important to answer this question.

On a scale of 1 to 5 do you agree that the tasks 1 - 3 work on your institute's library portal?

Strongly Disagree	1	2	3	4	5	Strongly Agree
☐	☐	☐	☐	☐	☐	

Question 8.

Please briefly explain your answer:

Question 9.

If you are a publisher it is important to answer this question.

On a scale of 1 to 5 do you agree that the tasks 4 - 7 work on your publisher's website?

Strongly Disagree	1	2	3	4	5	Strongly Agree
☐	☐	☐	☐	☐	☐	

Question 10.

Please briefly explain your answer:

Question 11.

In your opinion what accessibility requirements are necessary for the mobile web accessibility of Higher Education electronic texts for print impairments?

Survey Progress

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Back a page

Save and Finish

Once this button is pressed you will not be able edit your responses

The following simplified automated checks will be available as an accessible Word document at: <https://goo.gl/Y7hQkm>

Ethics reference number: **ERGO/FPSE/30291**

1. List of automated checks for device, mobile browser, and website

Visual Controls

- | |
|---|
| <ol style="list-style-type: none">1. High contrast can be altered.2. Text and background colour or themes can be altered.3. Margin width, line spacing, character spacing and full screen can be altered.4. Text size, font typeface, left justify, text reflow and zoom/magnification can be altered. |
|---|

Touch Controls

- | |
|---|
| <ol style="list-style-type: none">1. Check that the use of portrait or landscape mode can be altered.2. Check that screen reader focus can be moved through navigation elements. |
|---|

Audible Controls

- | |
|--|
| <ol style="list-style-type: none">1. Check that Text to Speech (TTS) and speech rate can be altered. |
|--|

Speech Controls

- | |
|---|
| <ol style="list-style-type: none">1. Check that speech recognition can be altered in search boxes and the mobile browser address bar. |
|---|

Appendix H: Ethics applications for the expert reviews

The following simplified user tasks will be available as an accessible Word document at:

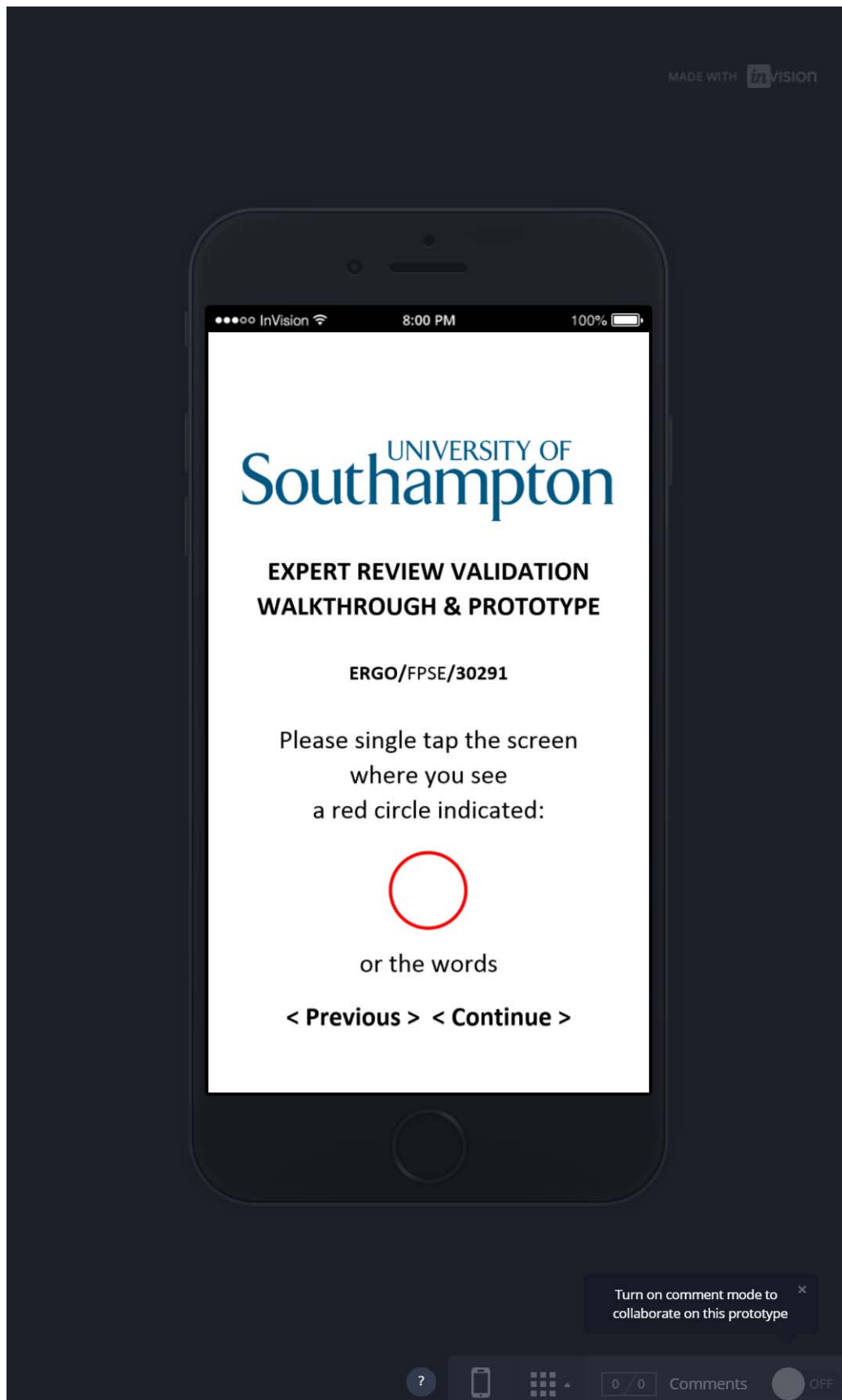
(<https://goo.gl/EFDmYh>). Ethics reference number: **ERGO/FPSE/30291**

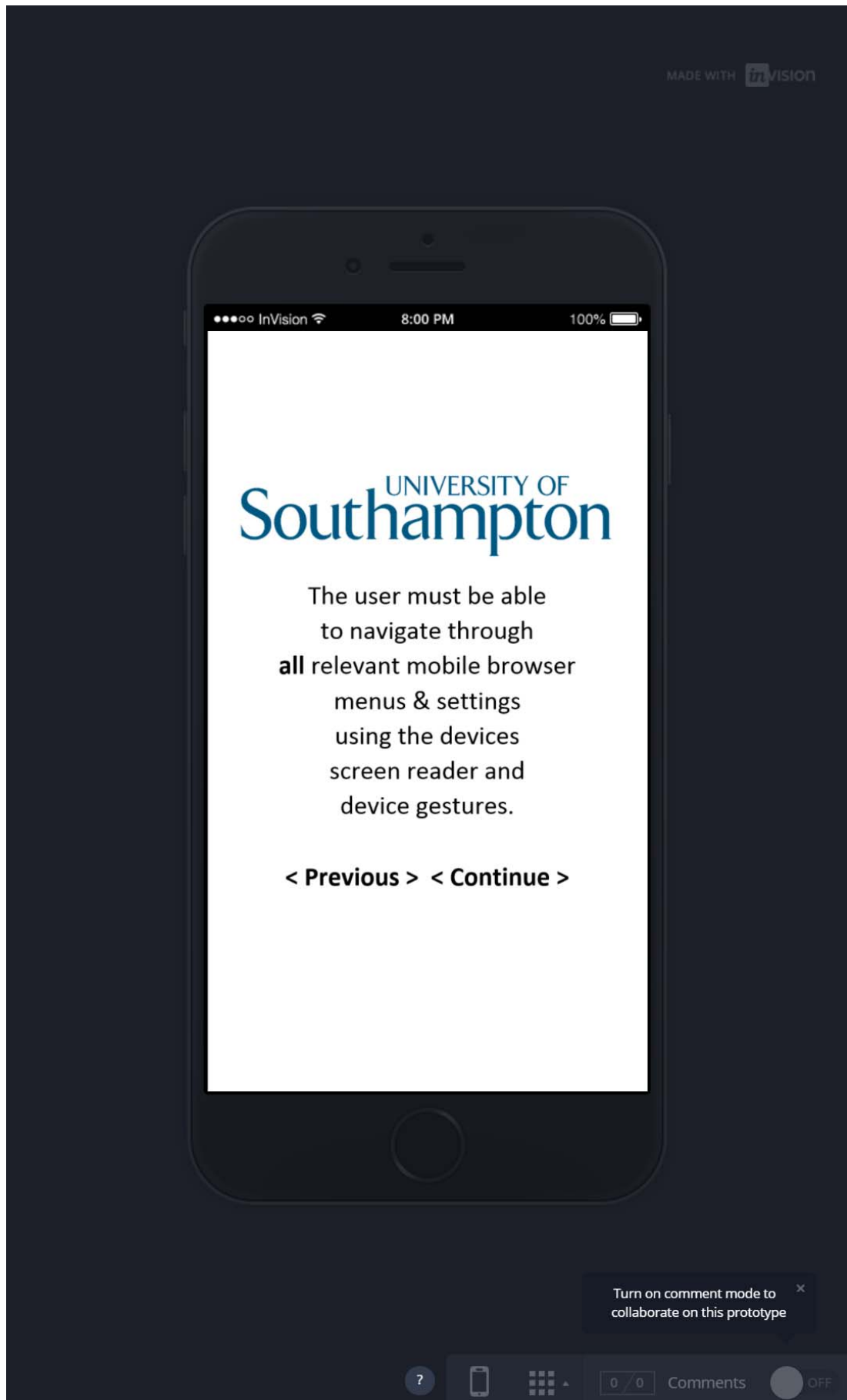
2. List of user tasks for Discovery & Download	
1. Search 1 and search 1 result(s)	Discovery: Search for and navigate to institute learning platform (Google search box & Google result links).
2. Institute authentication	Using a single sign in (such as Shibboleth or Athens) login to the institute library with username, password, and sign in button.
3. Institute library portal steps	Navigate through the library resources to the academic publisher's website.
4. Search 2 and search 2 result(s)	Through single sign in to search for and navigate to the journal paper preview link on the publishers website. Publishers need to ensure that the user is taken directly to the paper searched for and not a general journal page.
5. Preview paper abstract	Read preview paper abstract made available on the academic publishers website.
6. Read accessibility metadata prior to download	Currently not available on vendors websites. The prototype provides a demonstration of this feature.
7. Search 2 result	Download: Select download link for journal paper on academic publisher's website.
8. Manage downloads	Navigate through website options for local device download or transfer to third party cloud storage.

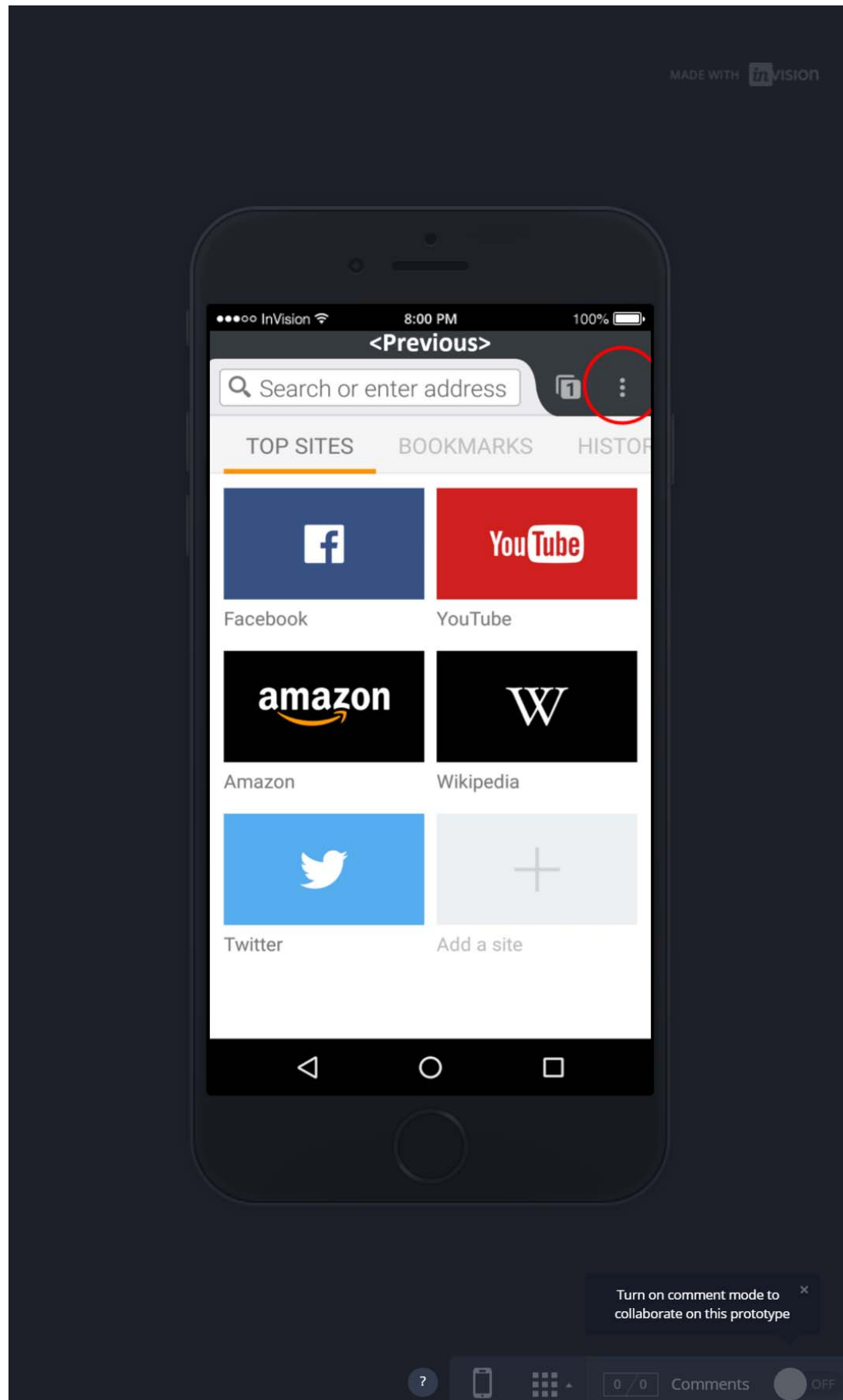
The full dataset for the Expert Review Two online survey can be found in: N.E. (2019) Dataset for: Automatically evaluating the mobile web accessibility of Higher Education electronic texts for print impairments. University of Southampton doi: 10.5258/SOTON/D1064 [Dataset] under 'iSurveyID24151DATA.csv'. This is also supported by the full quantitative results 'ExpertReview2SurveyResults.xlsx' under the same DOI.

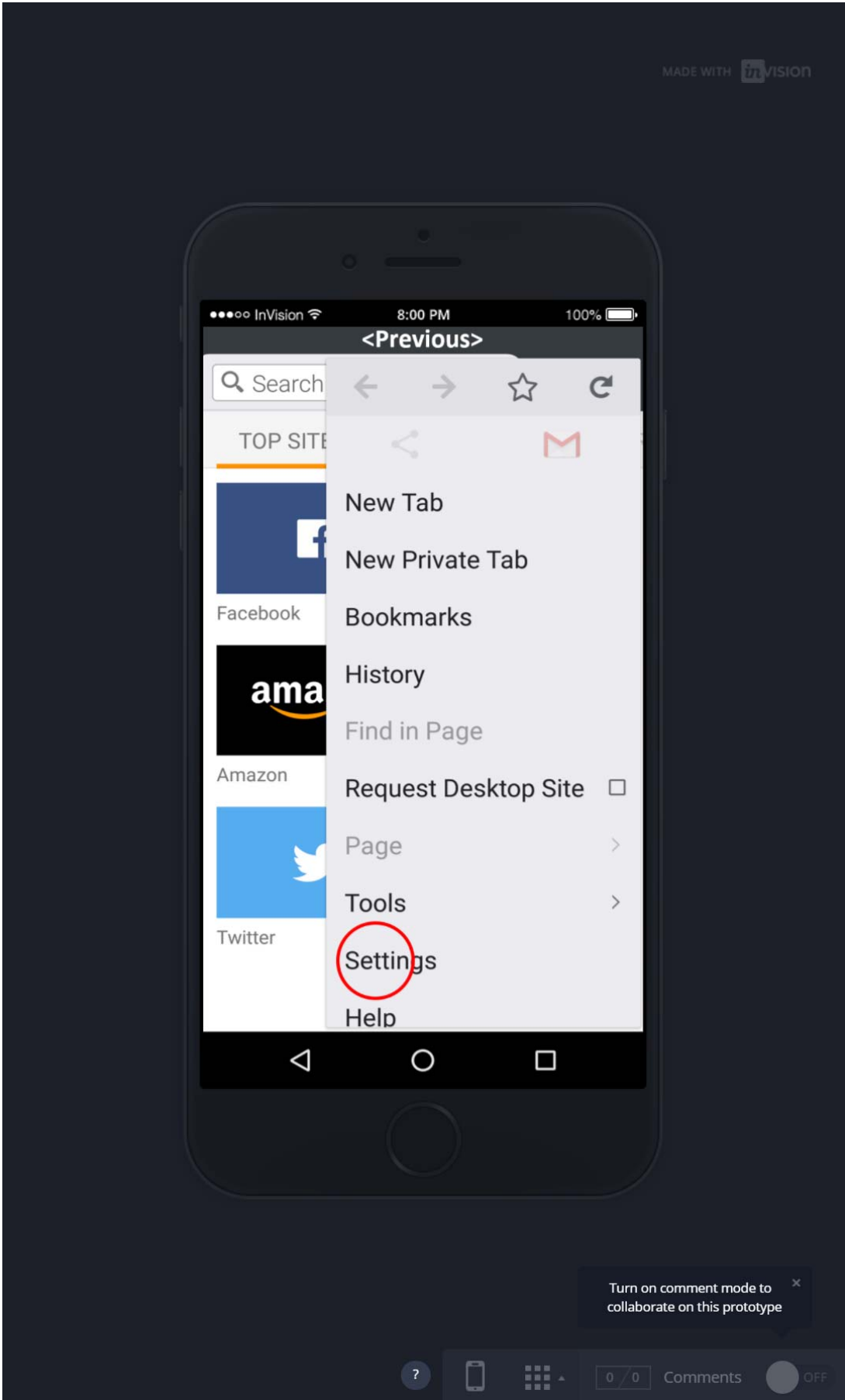
The mapping between the comments made by the individual participants in Expert Review Two and the published research findings can be found in: N.E. (2019) Dataset for: Automatically evaluating the mobile web accessibility of Higher Education electronic texts for print impairments. University of Southampton doi: 10.5258/SOTON/D1064 [Dataset] under 'ExpertReview2BackgroundMapping.xlsx'.

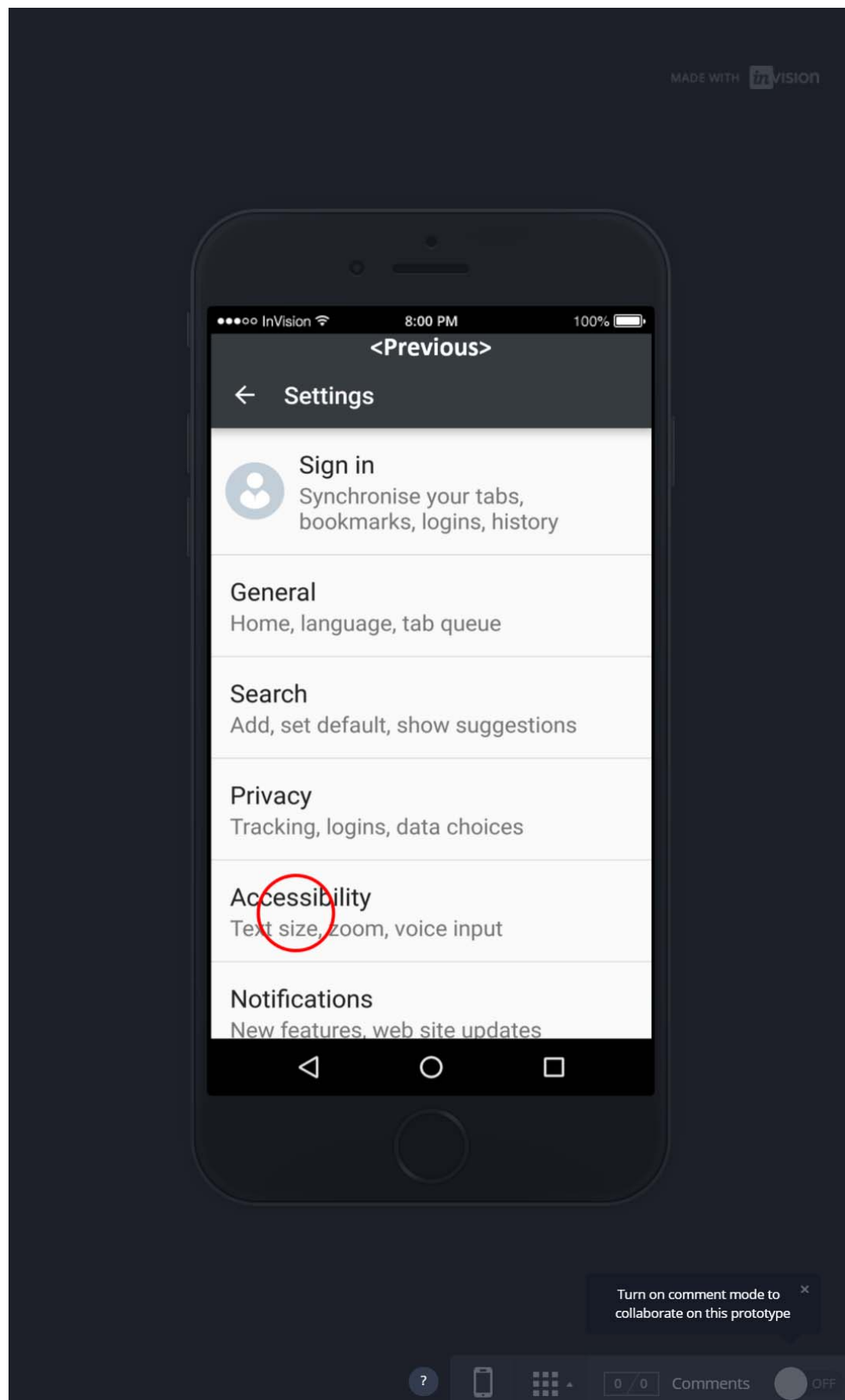
The following are screenshots, indicating exactly what the expert will see either on a desktop/laptop or smartphone/tablet for the walkthrough and prototype available at: <https://invis.io/7VD7CGCTR>

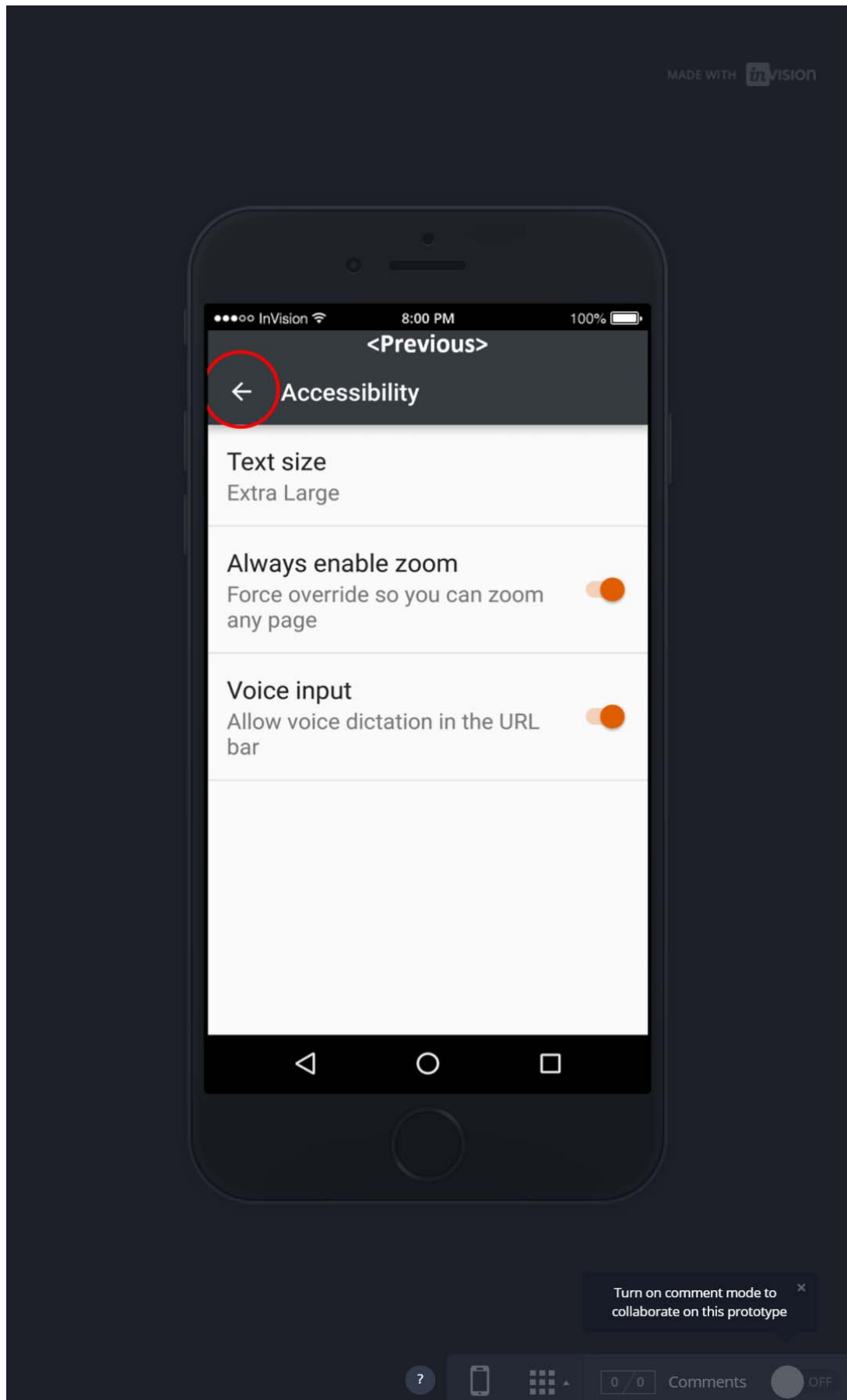


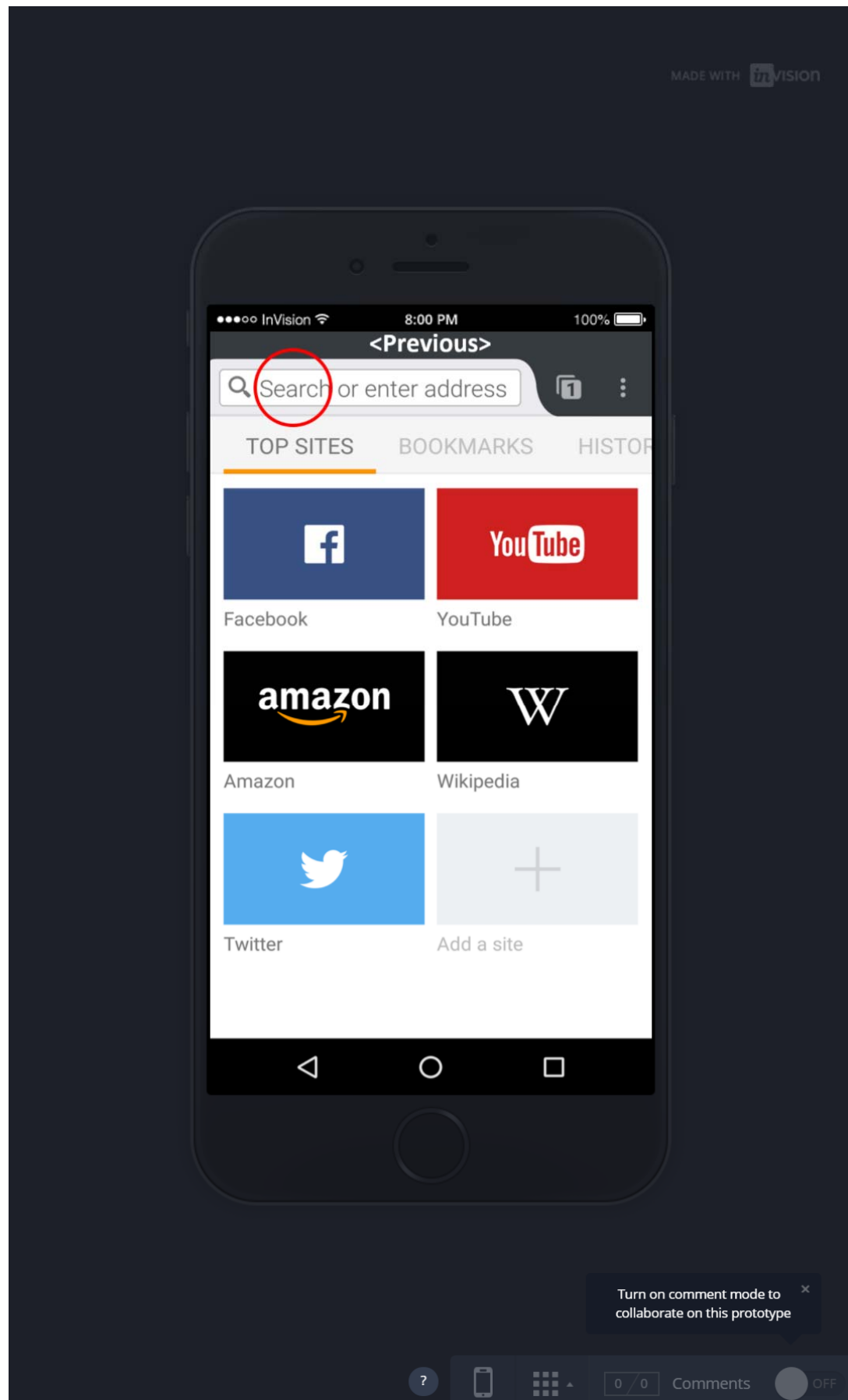


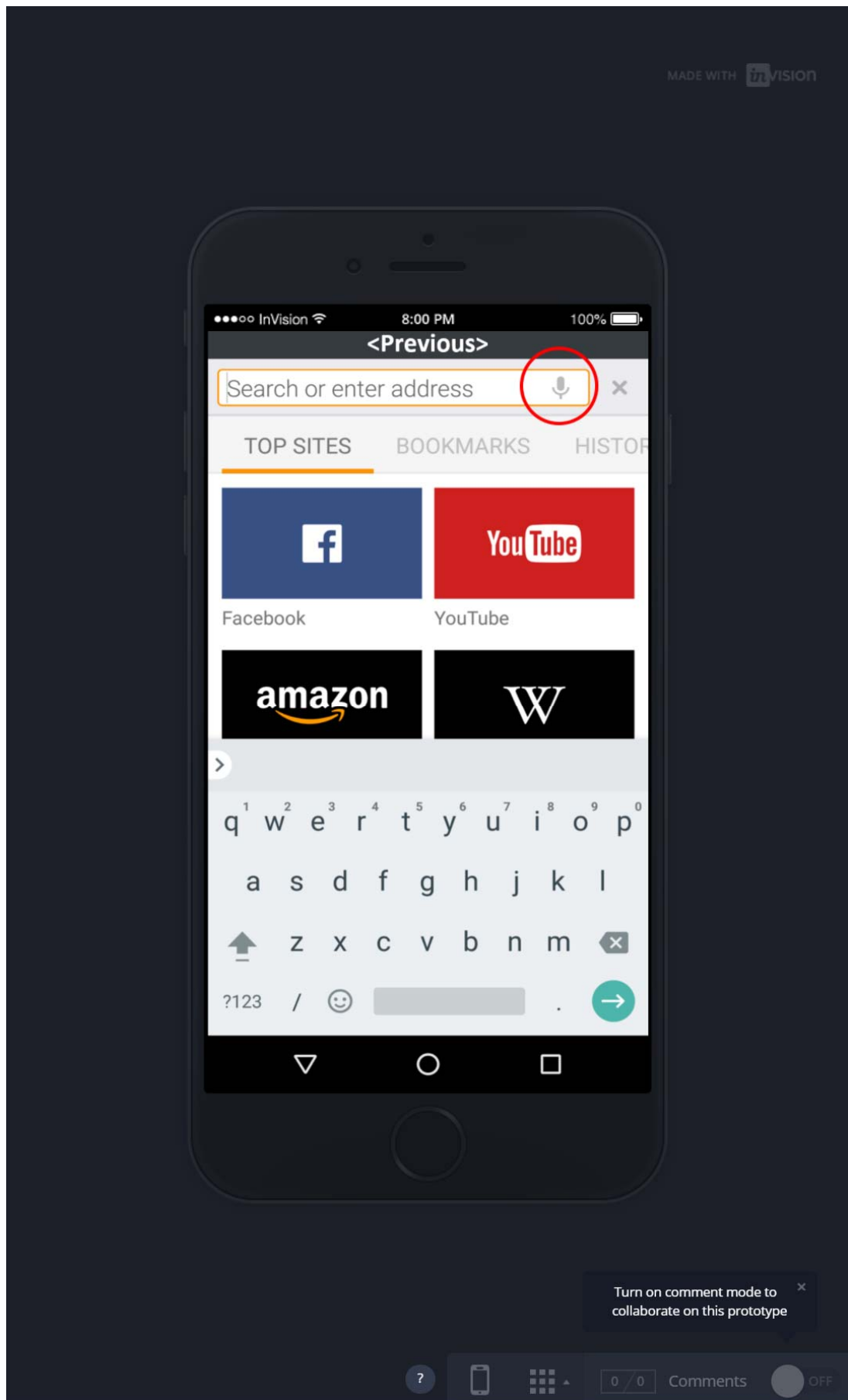


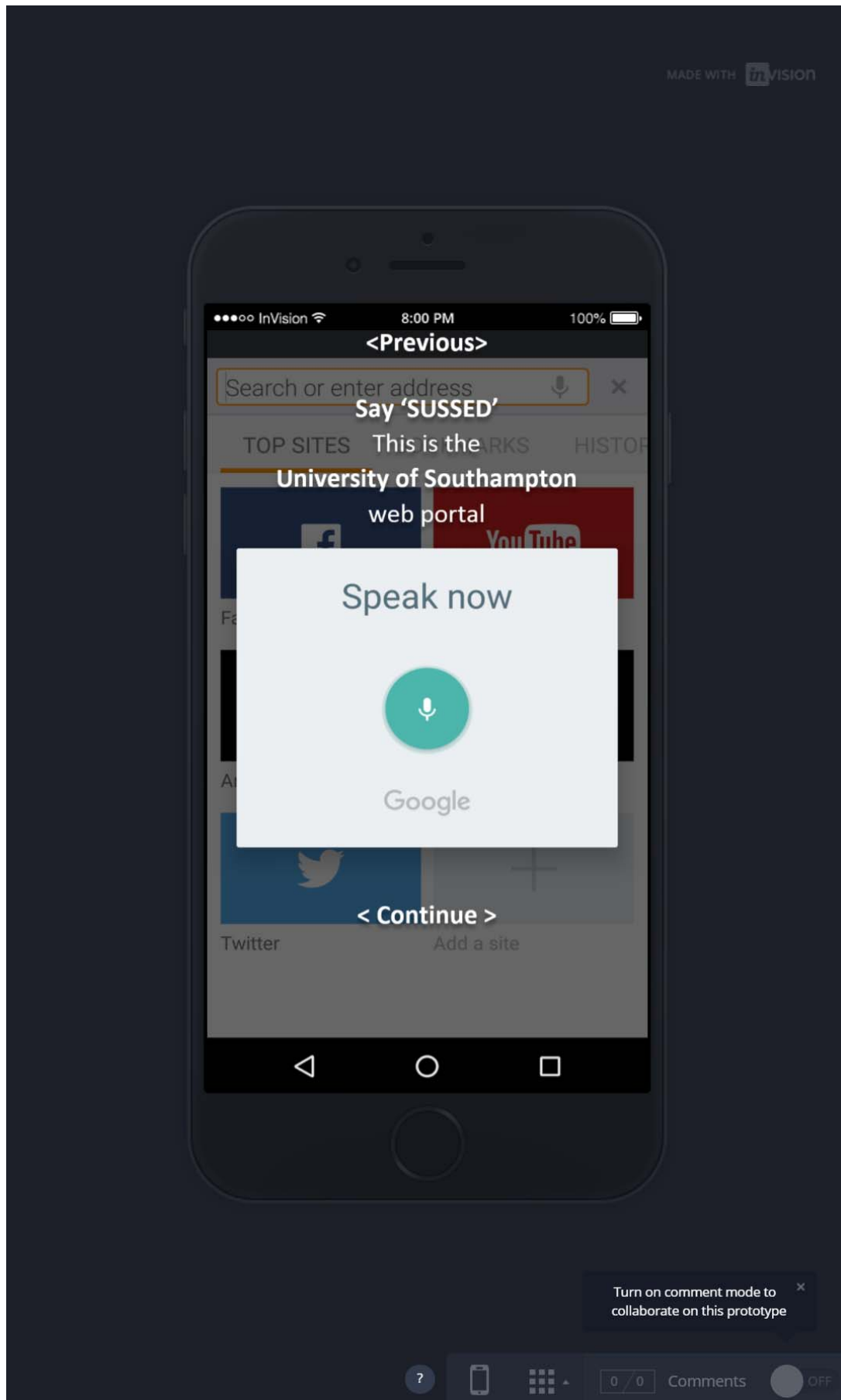


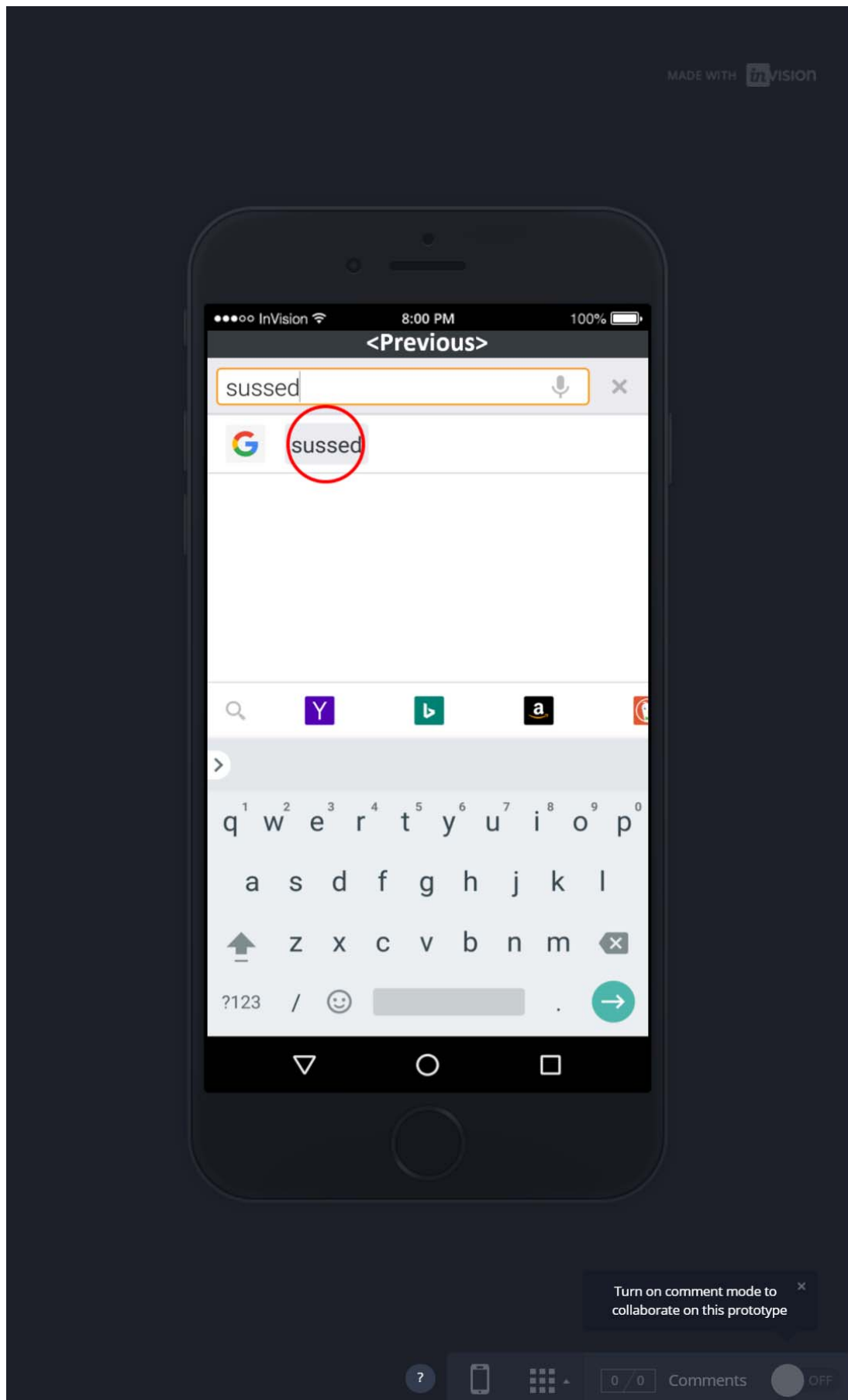


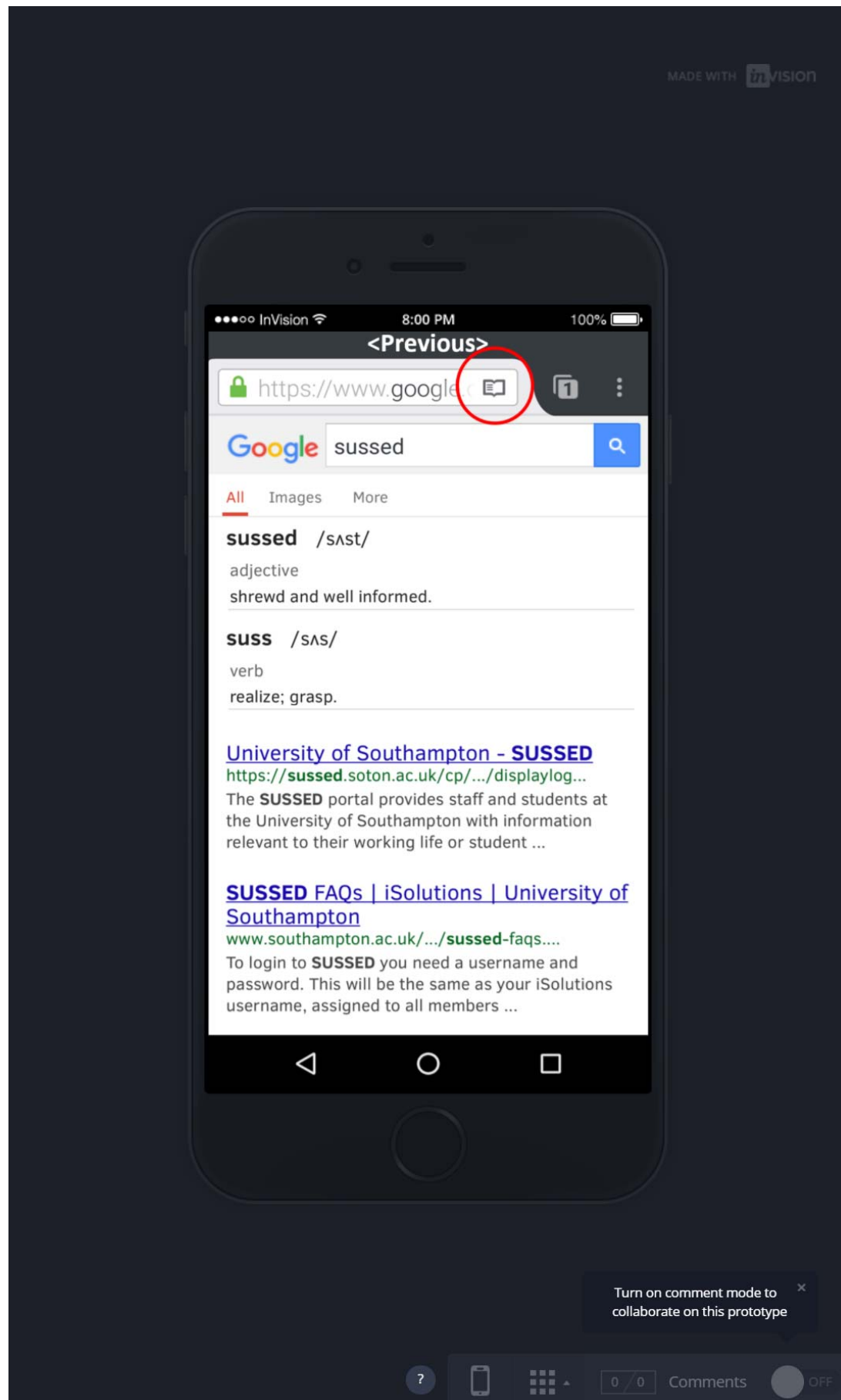


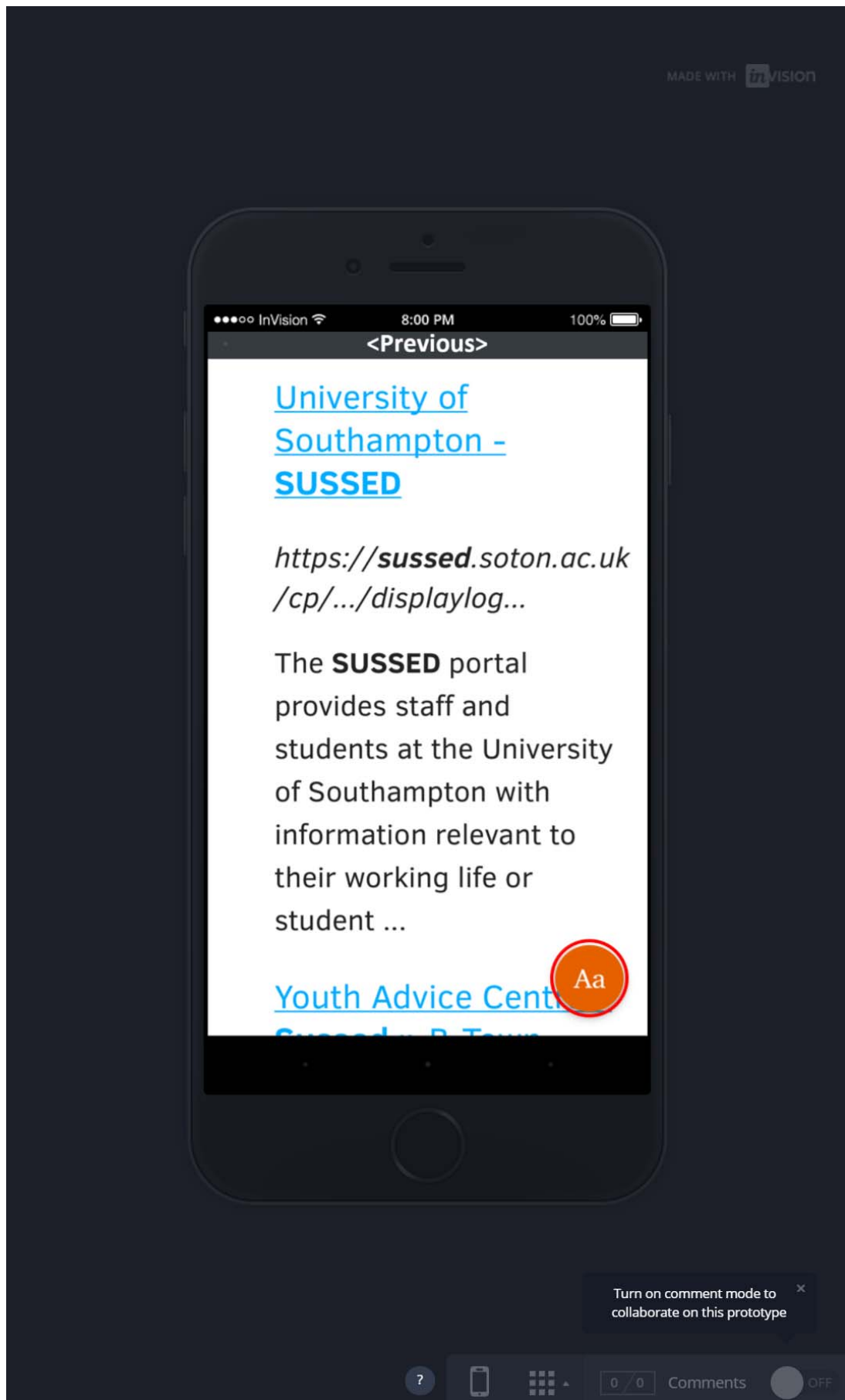


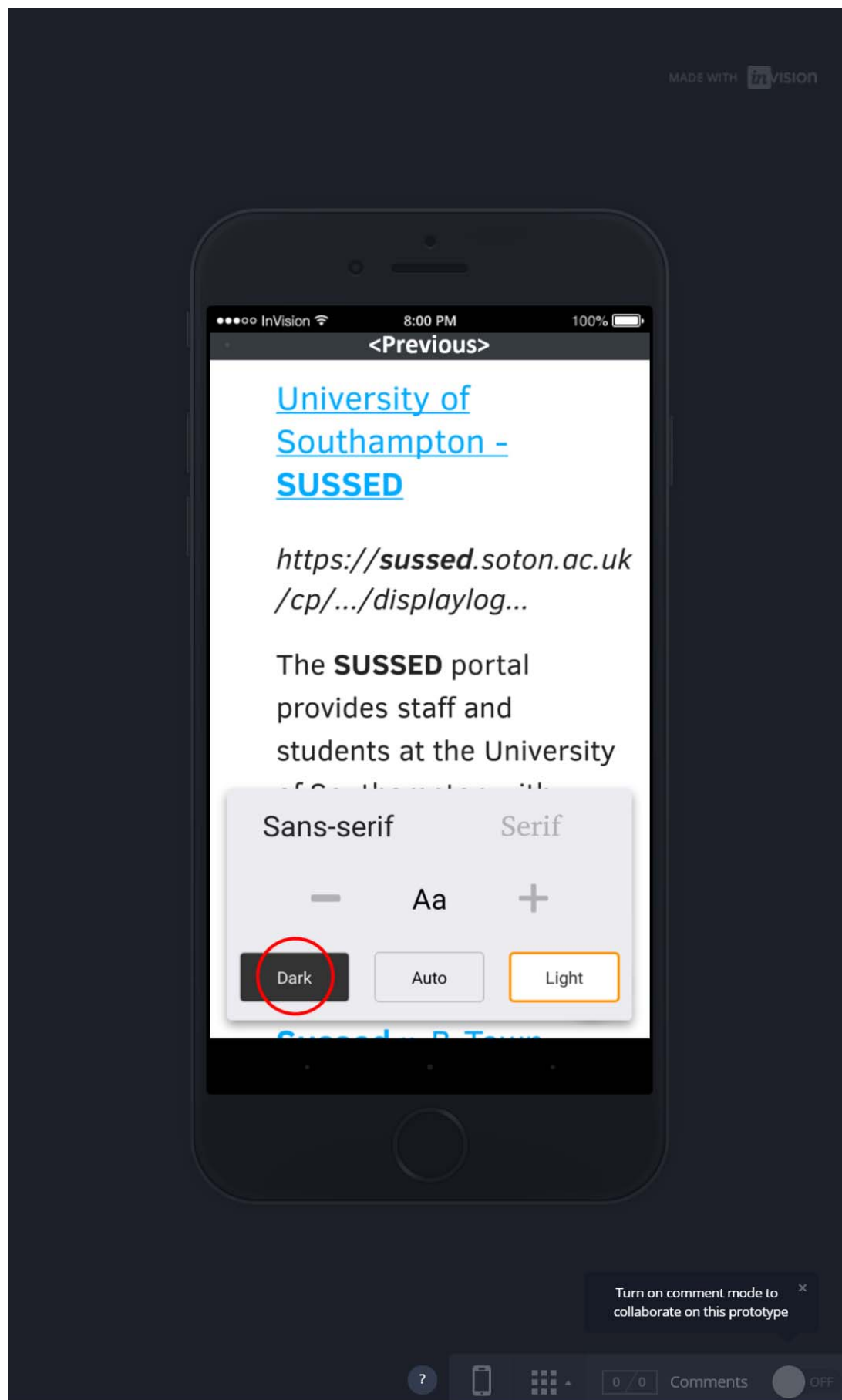


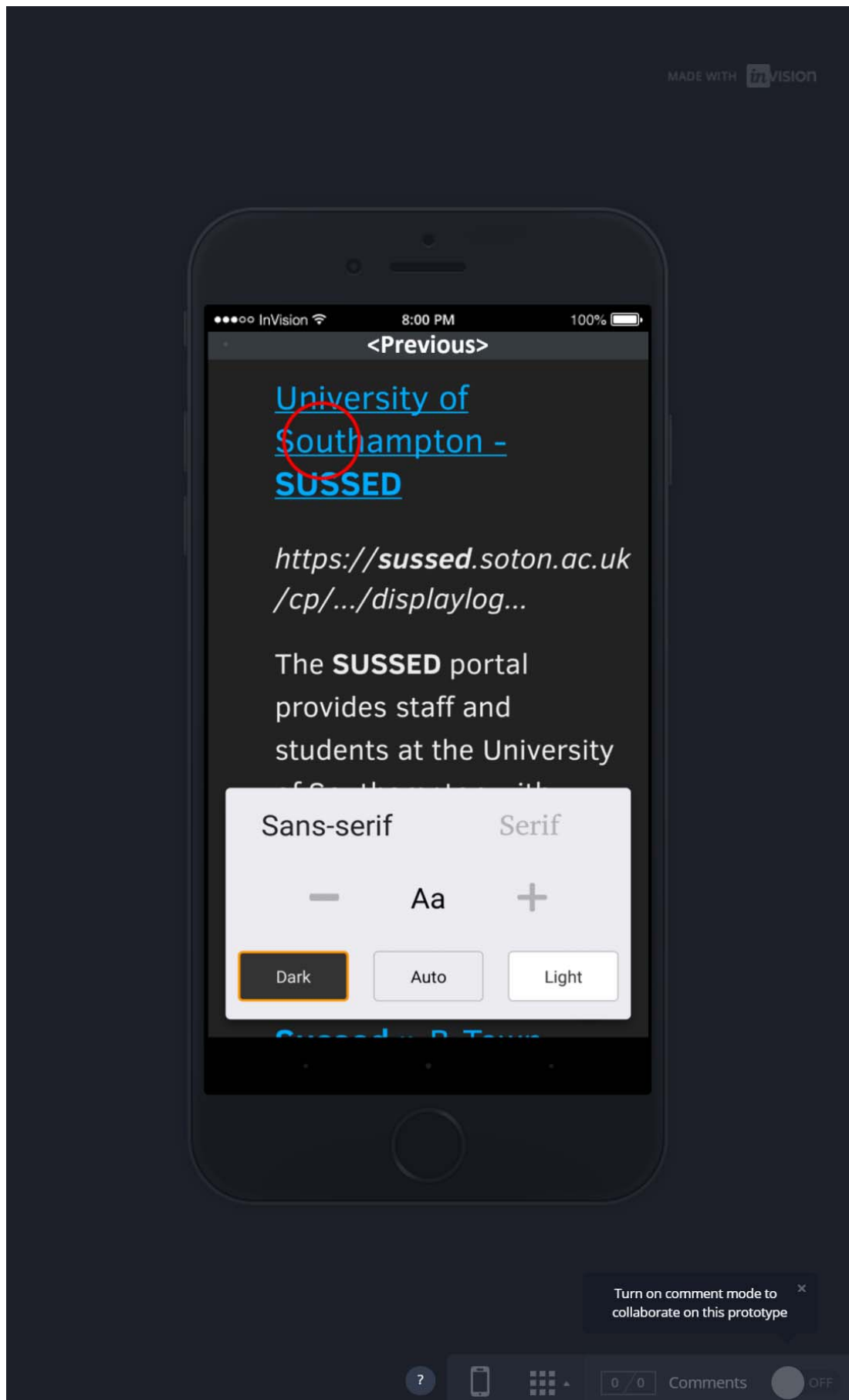


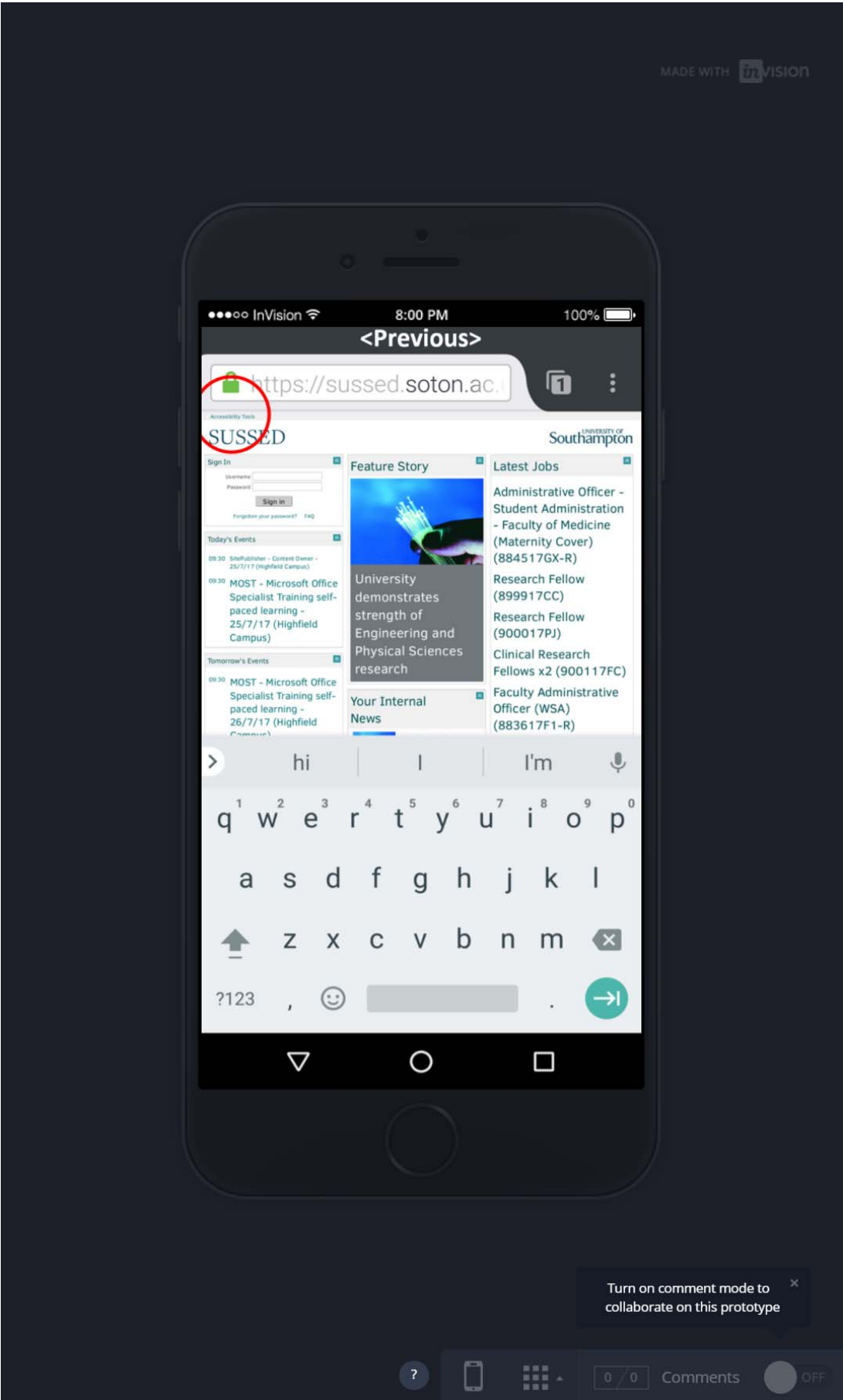


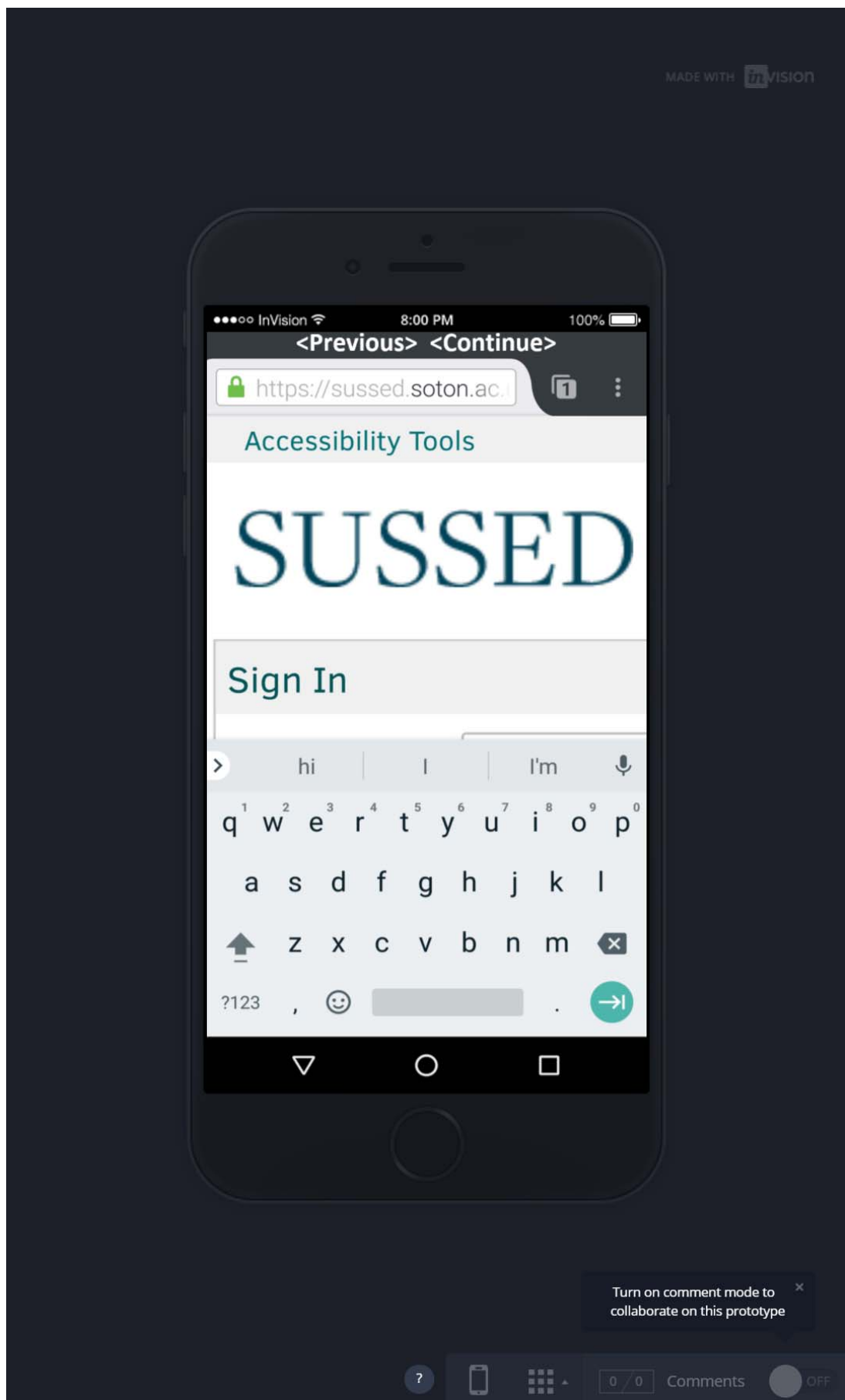


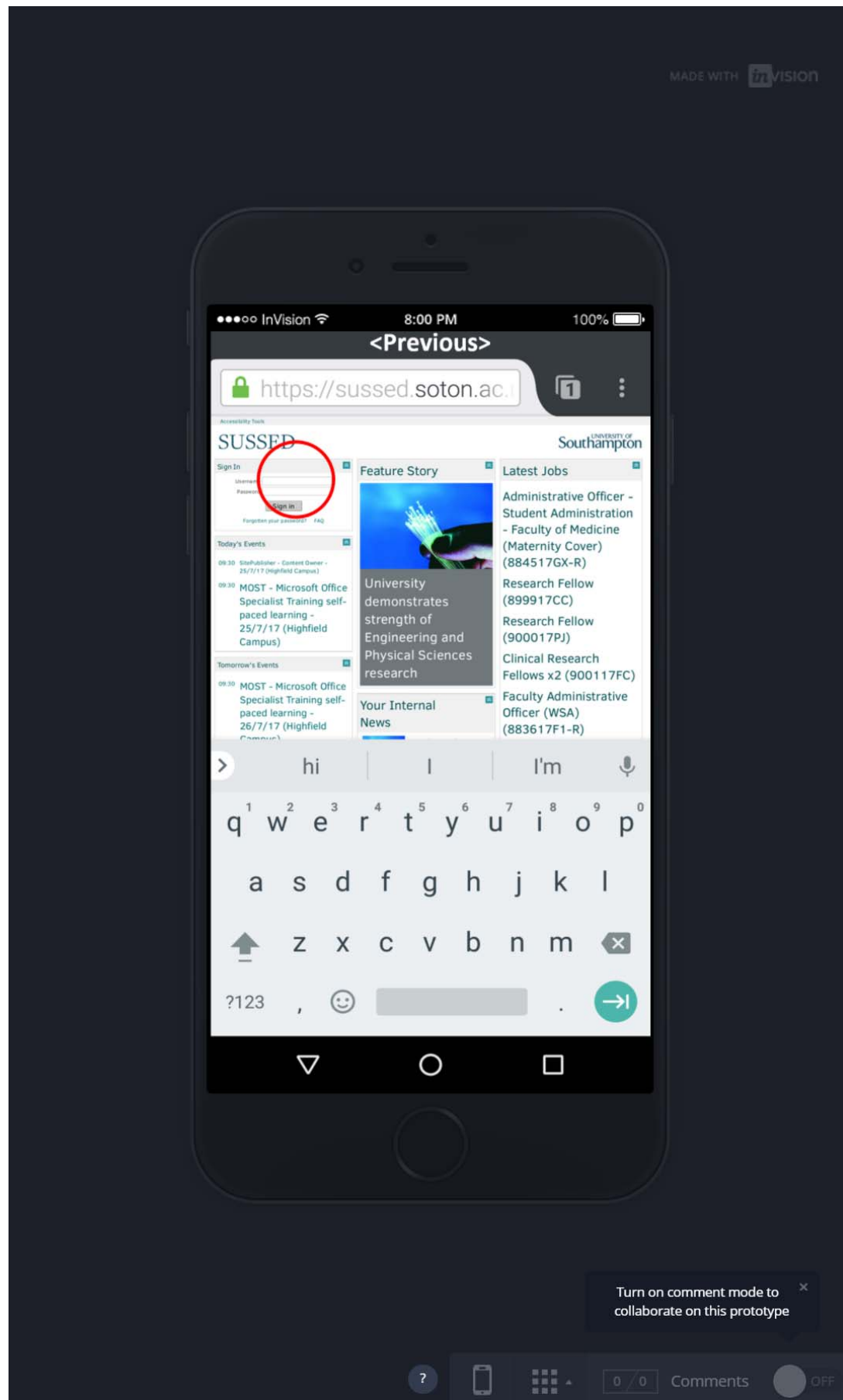


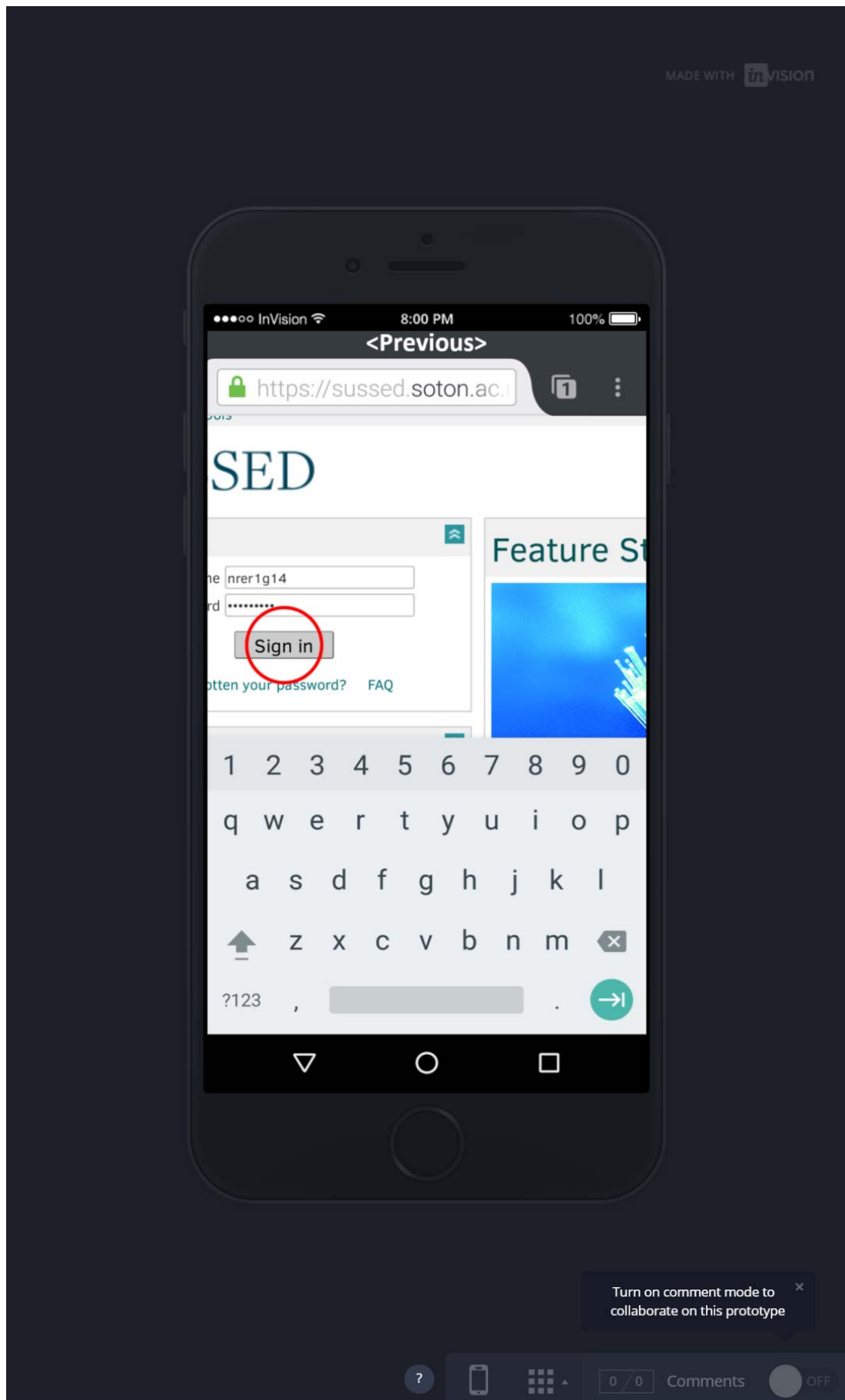


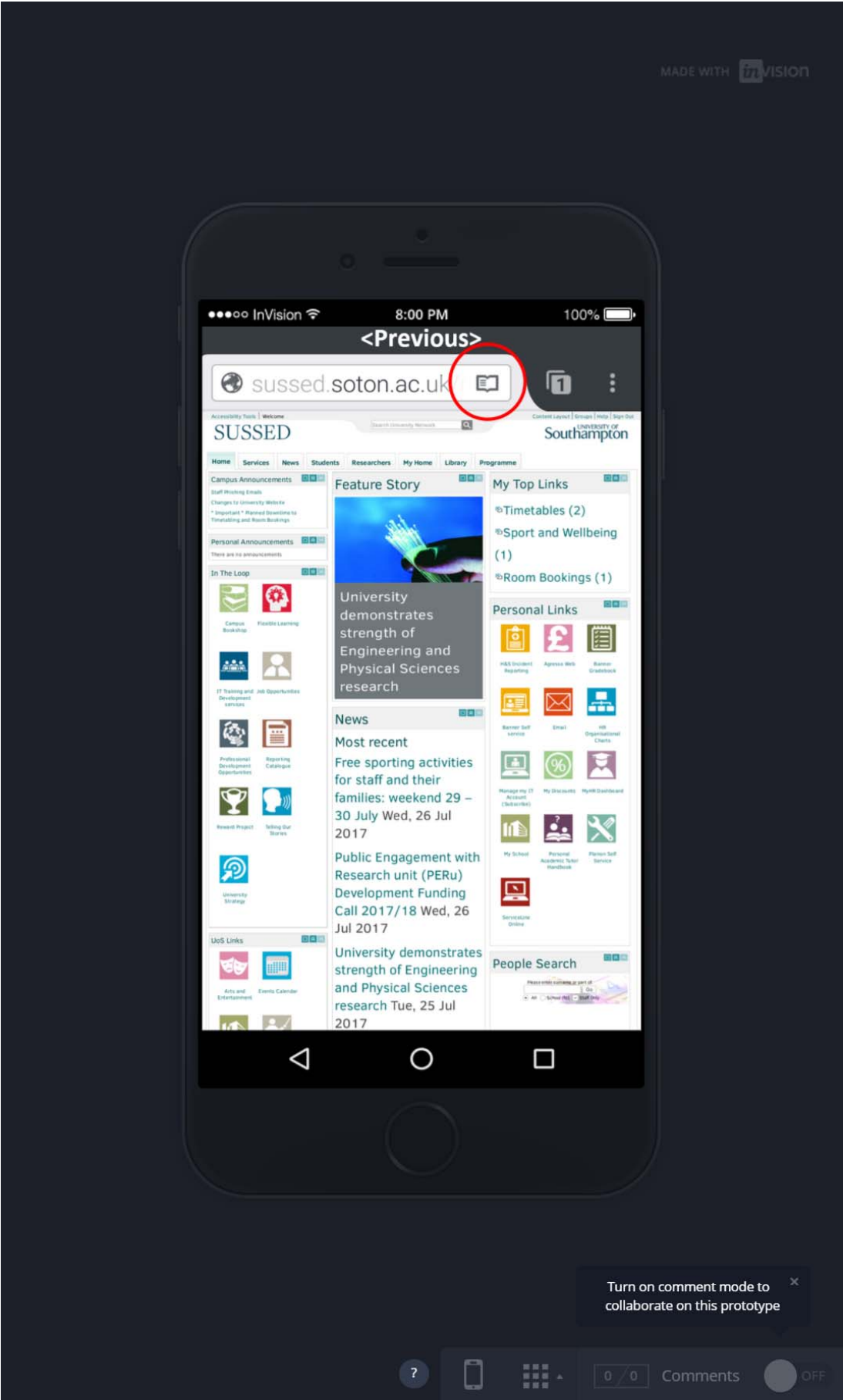


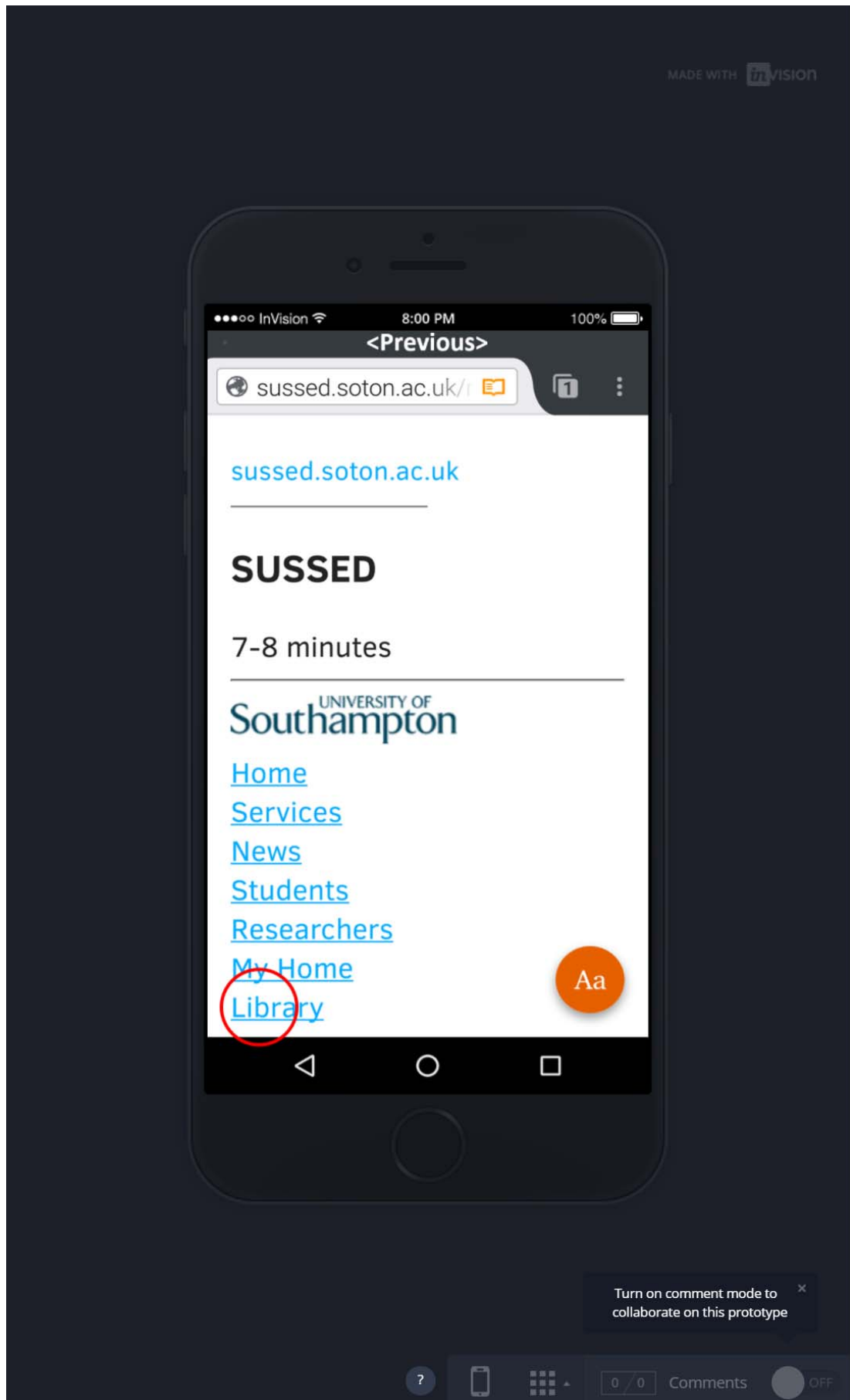


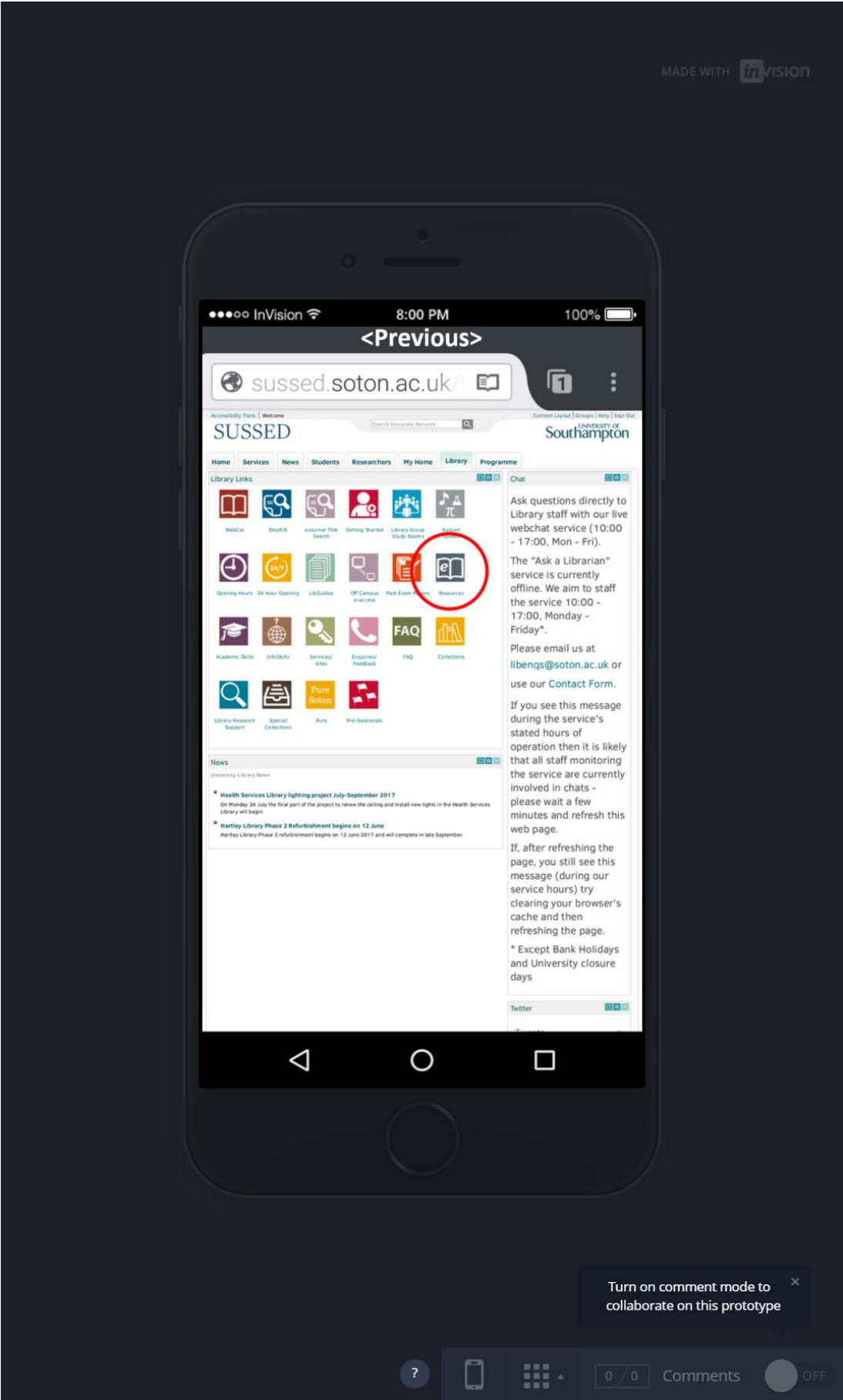


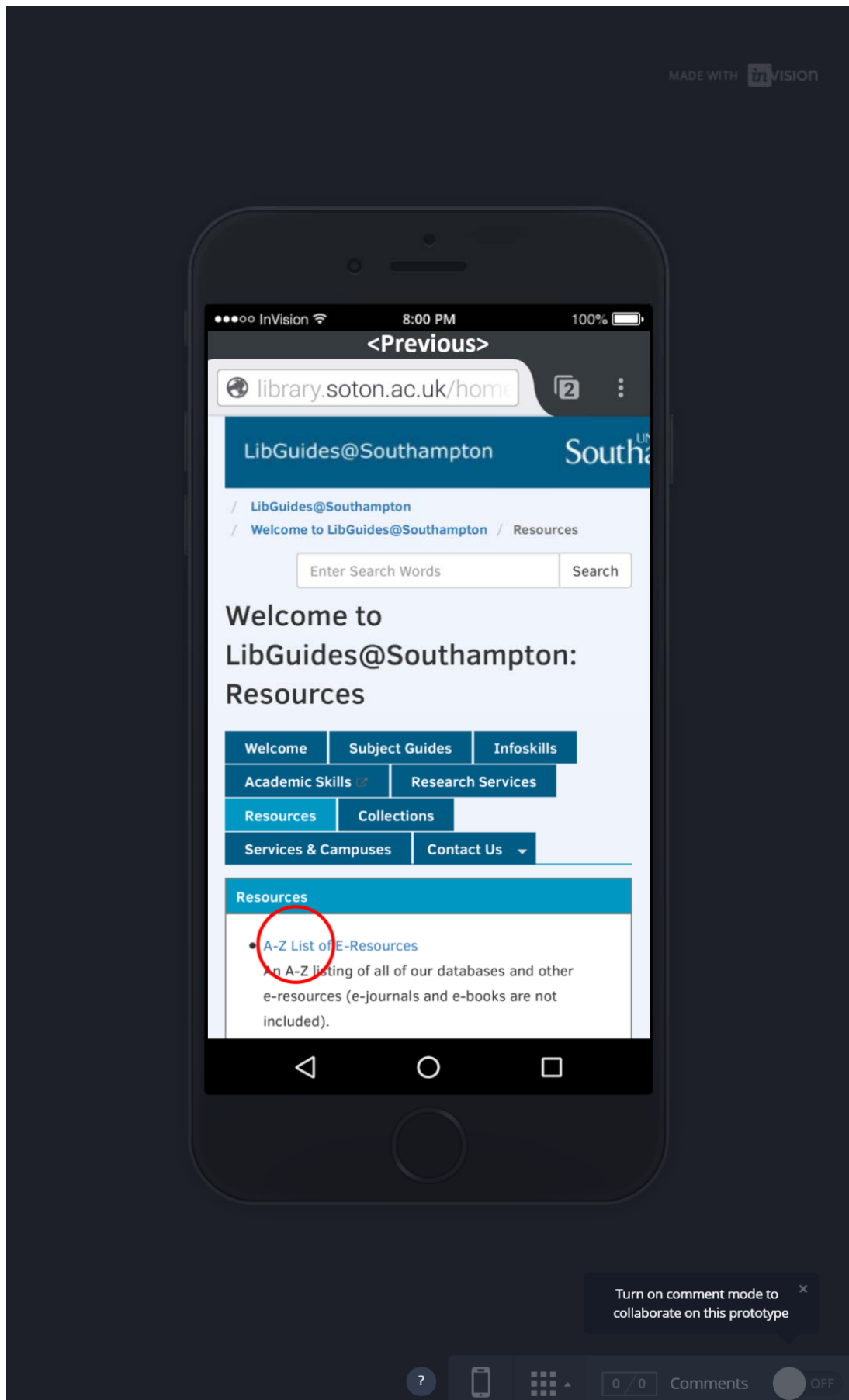


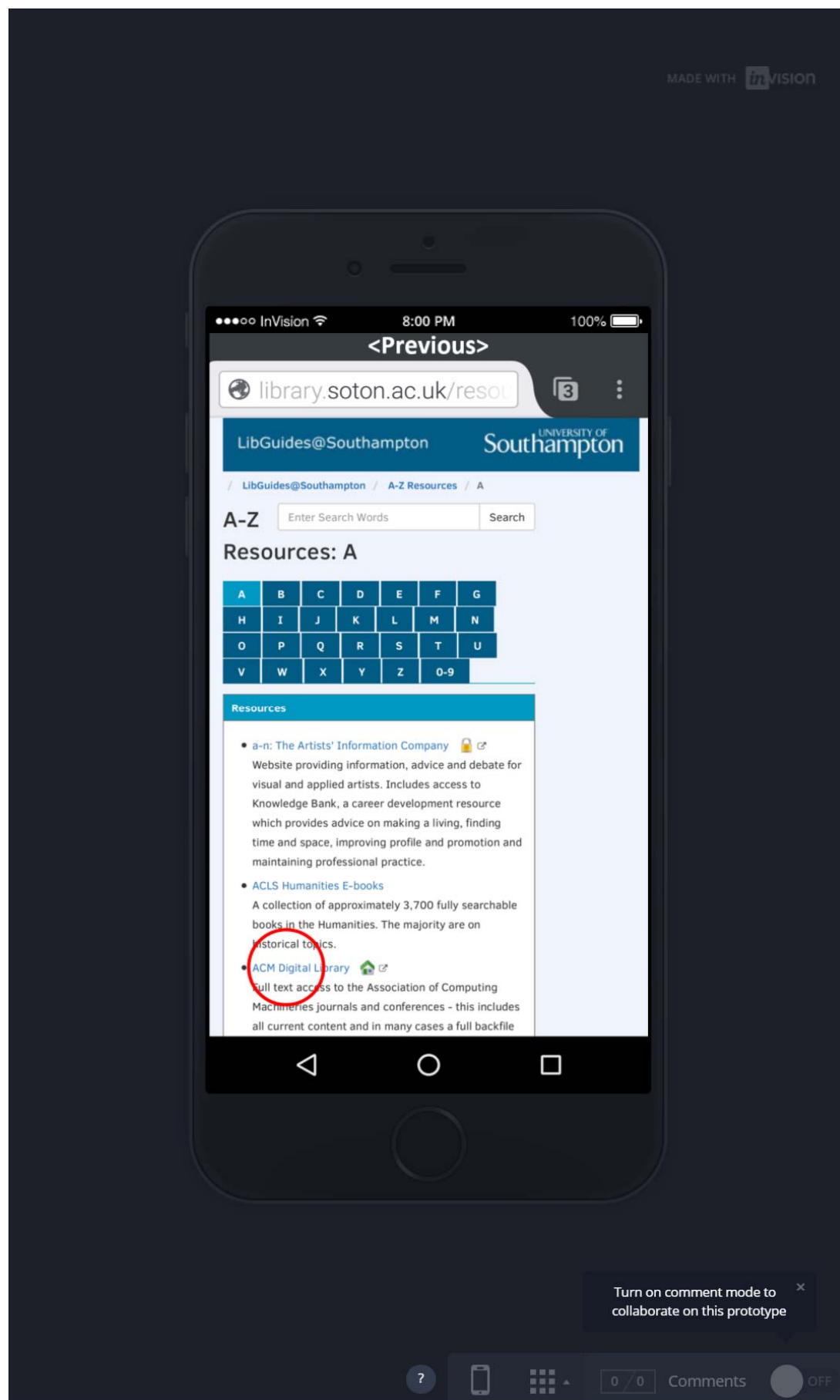


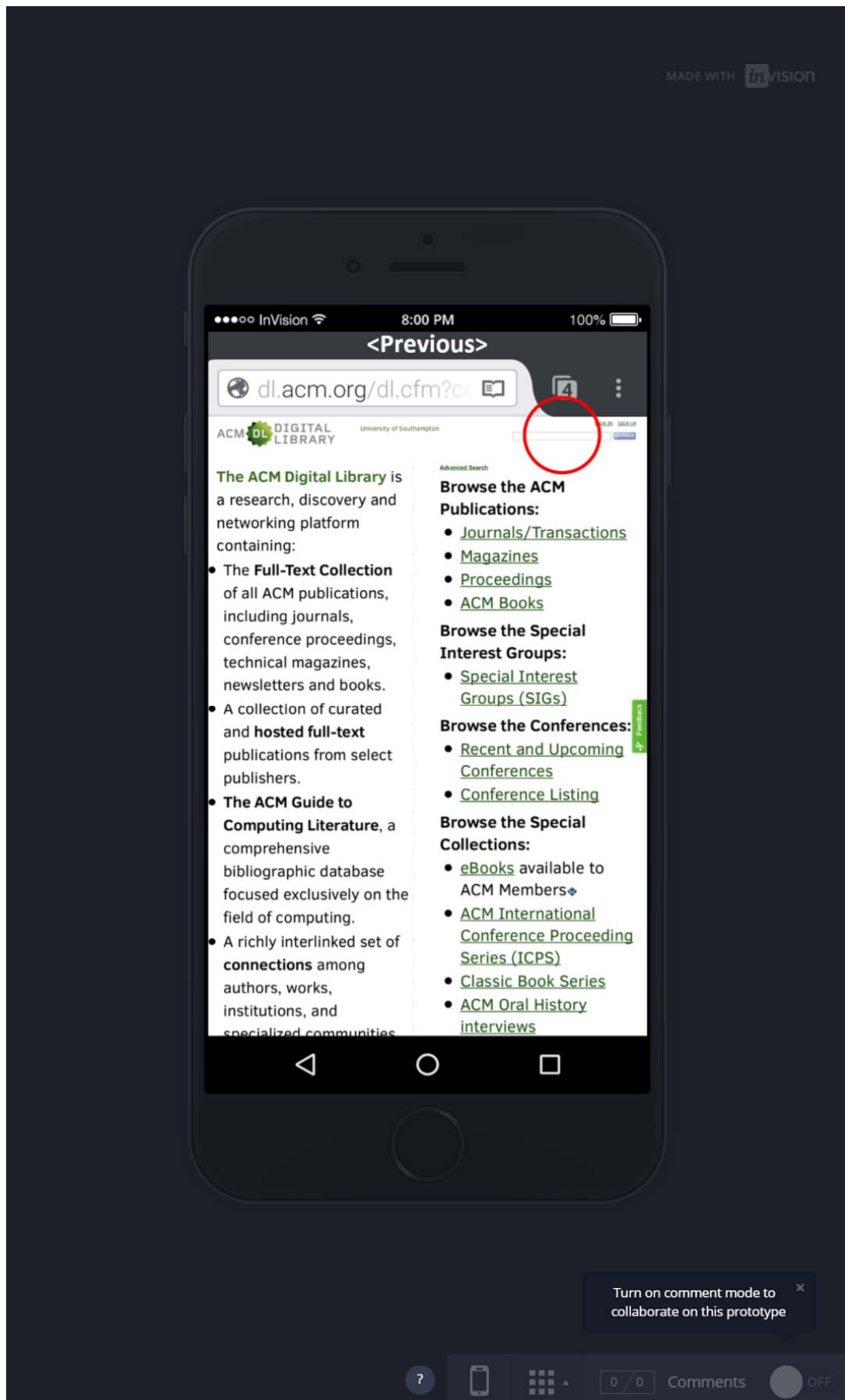


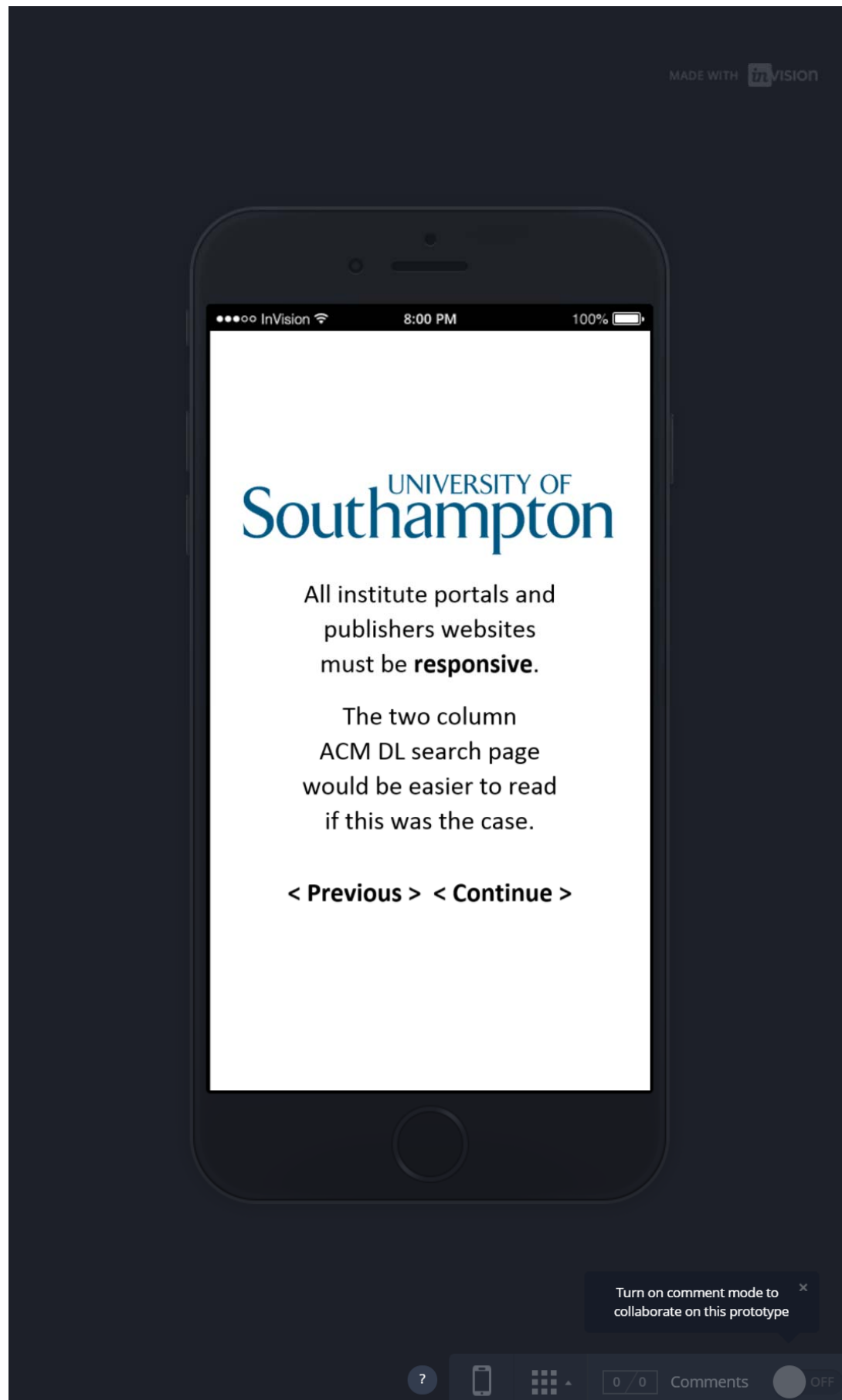


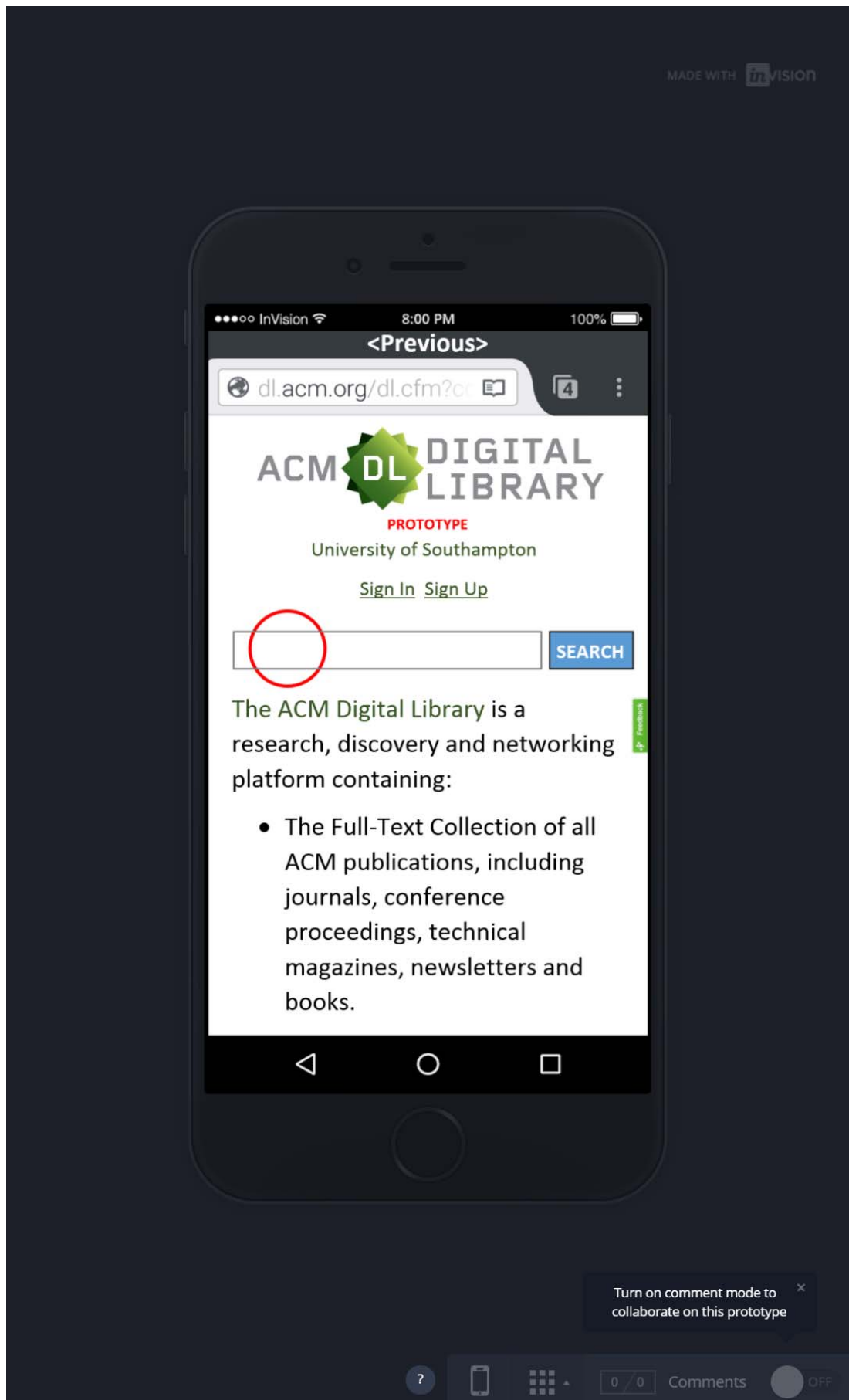


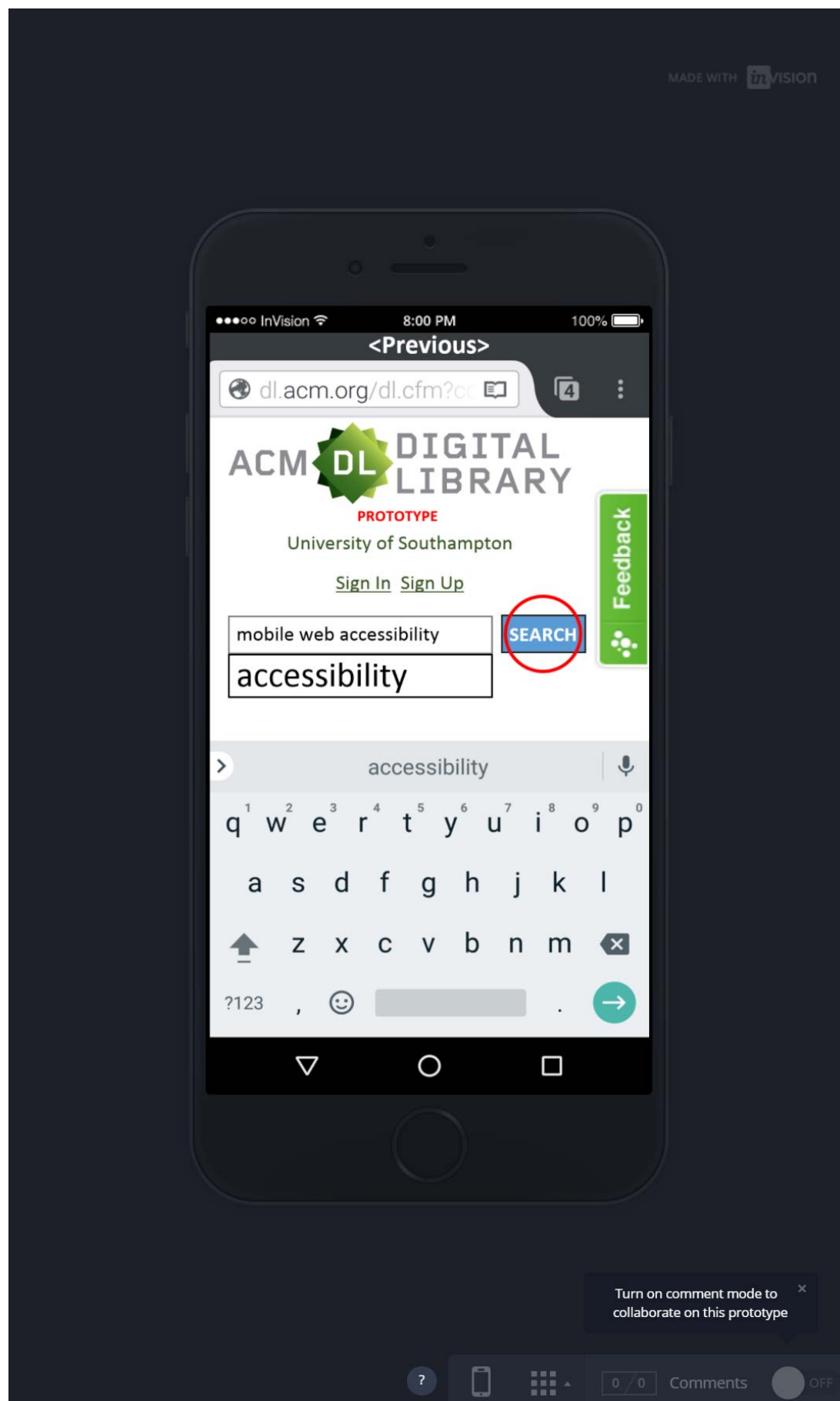


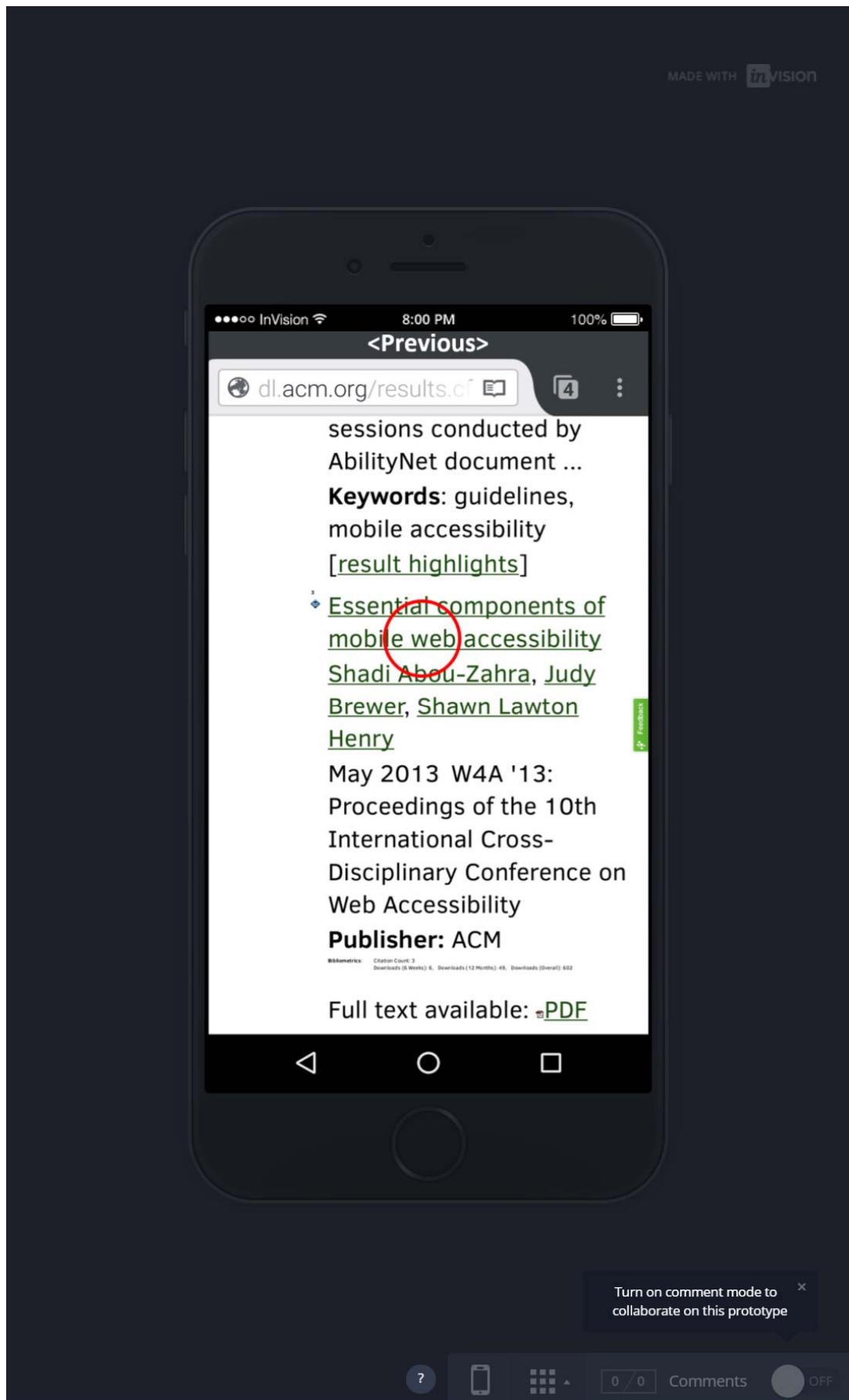


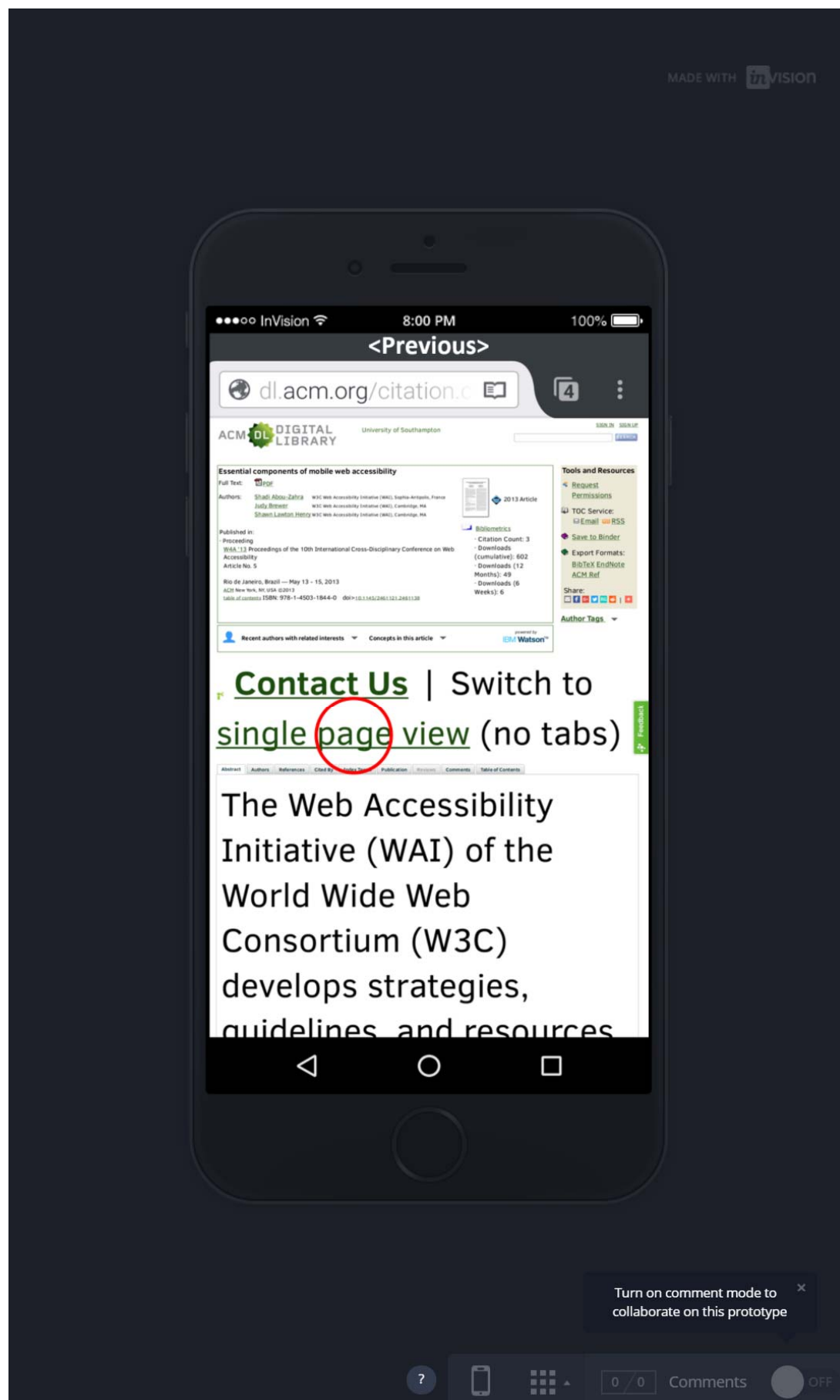


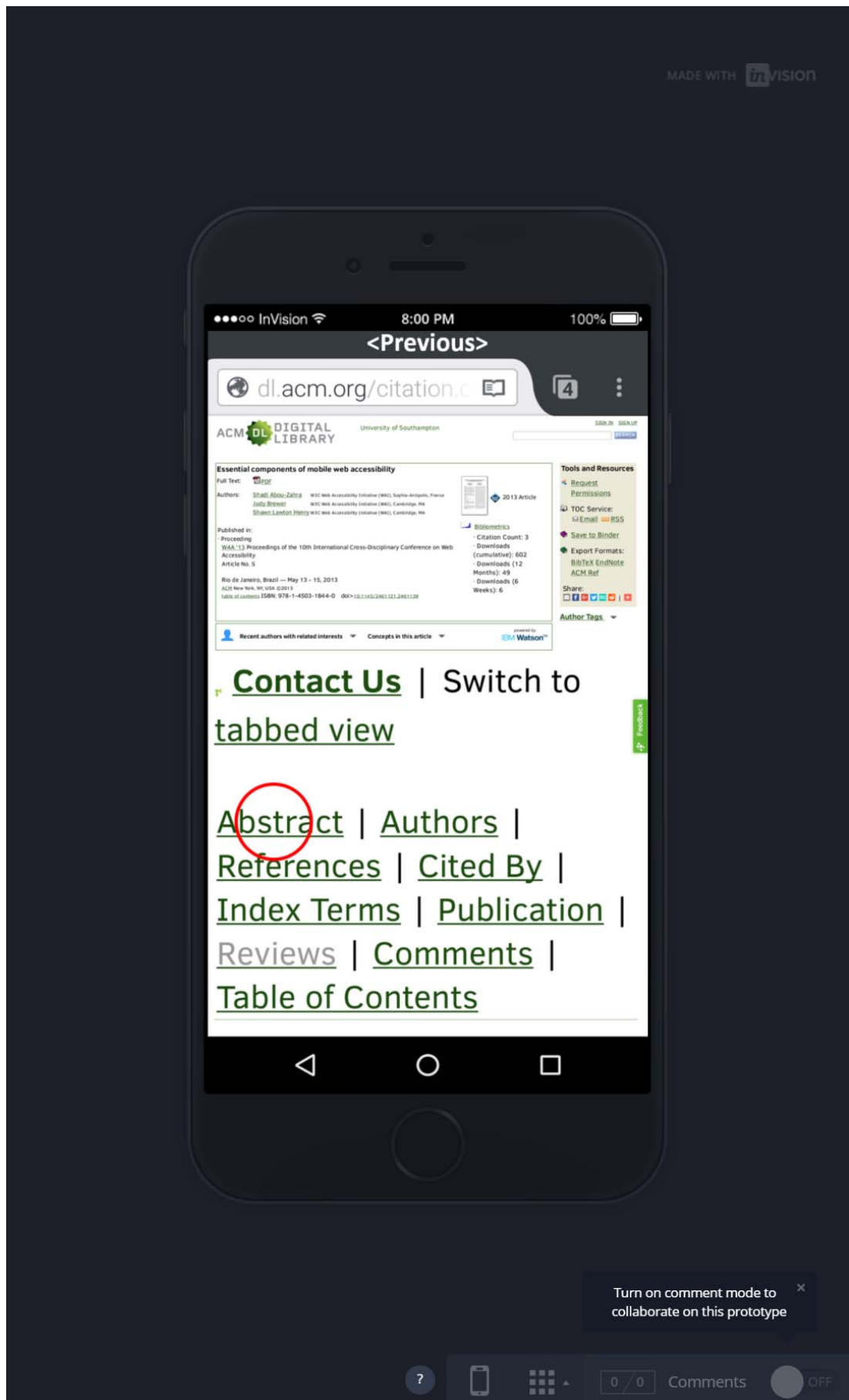


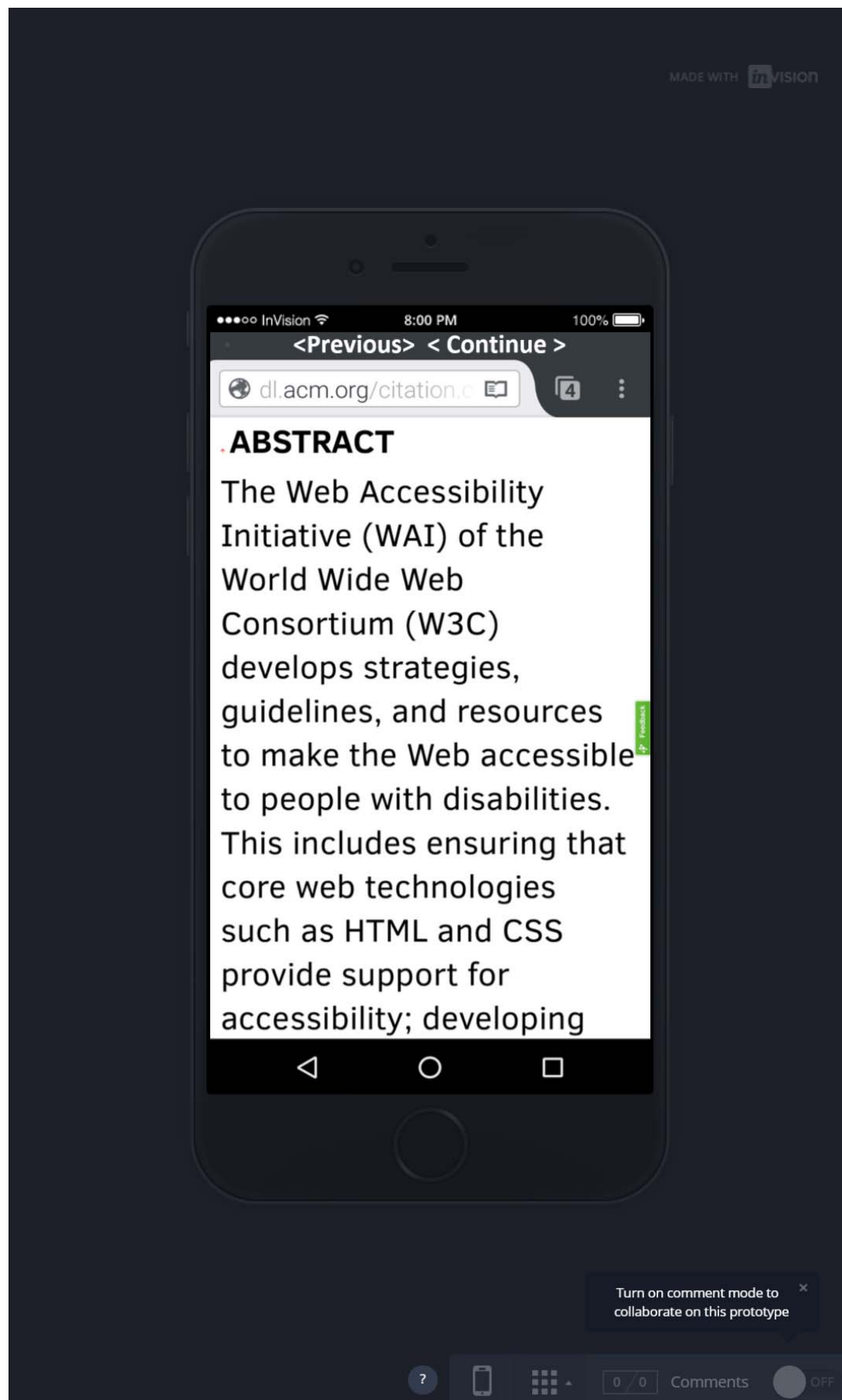


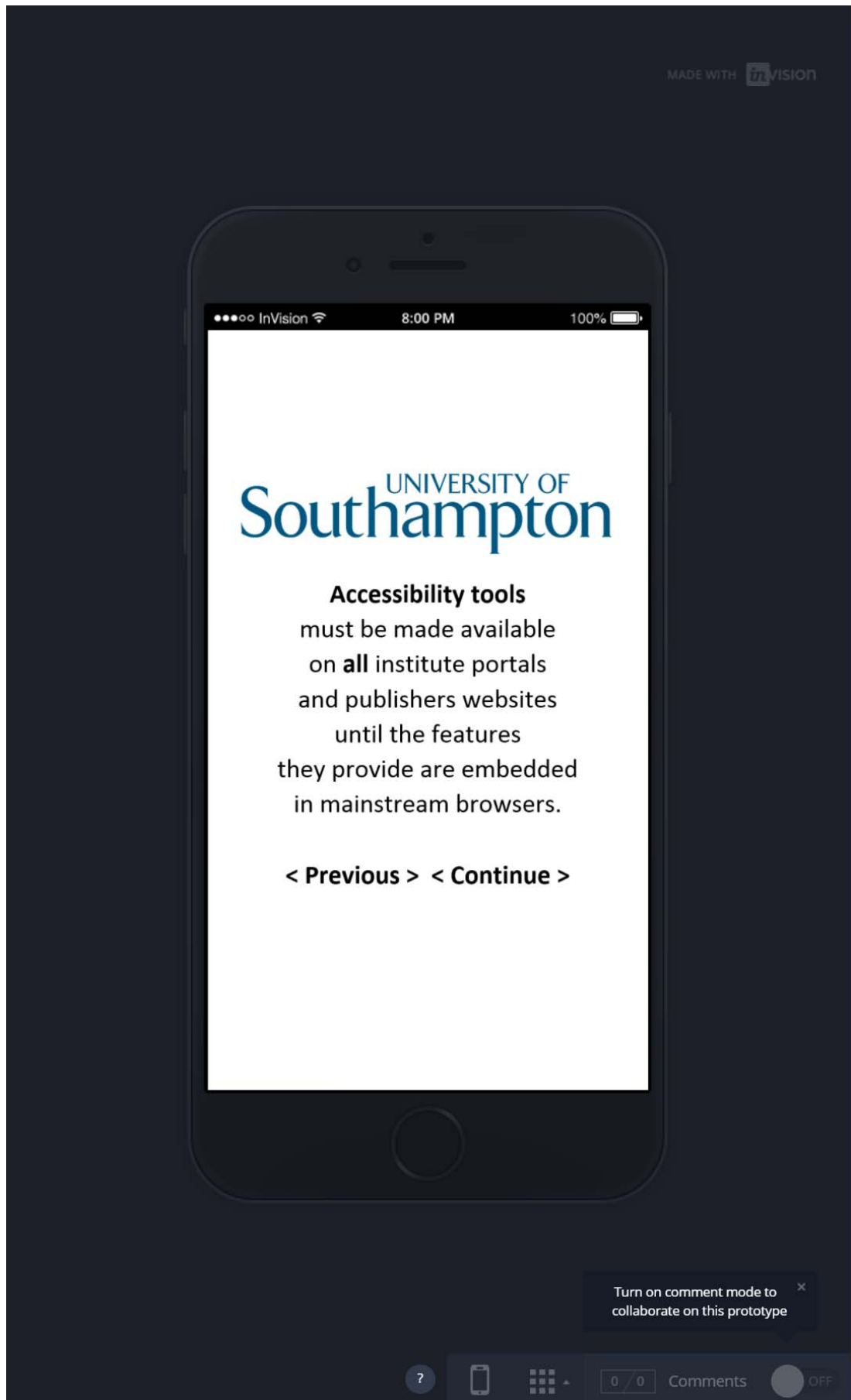


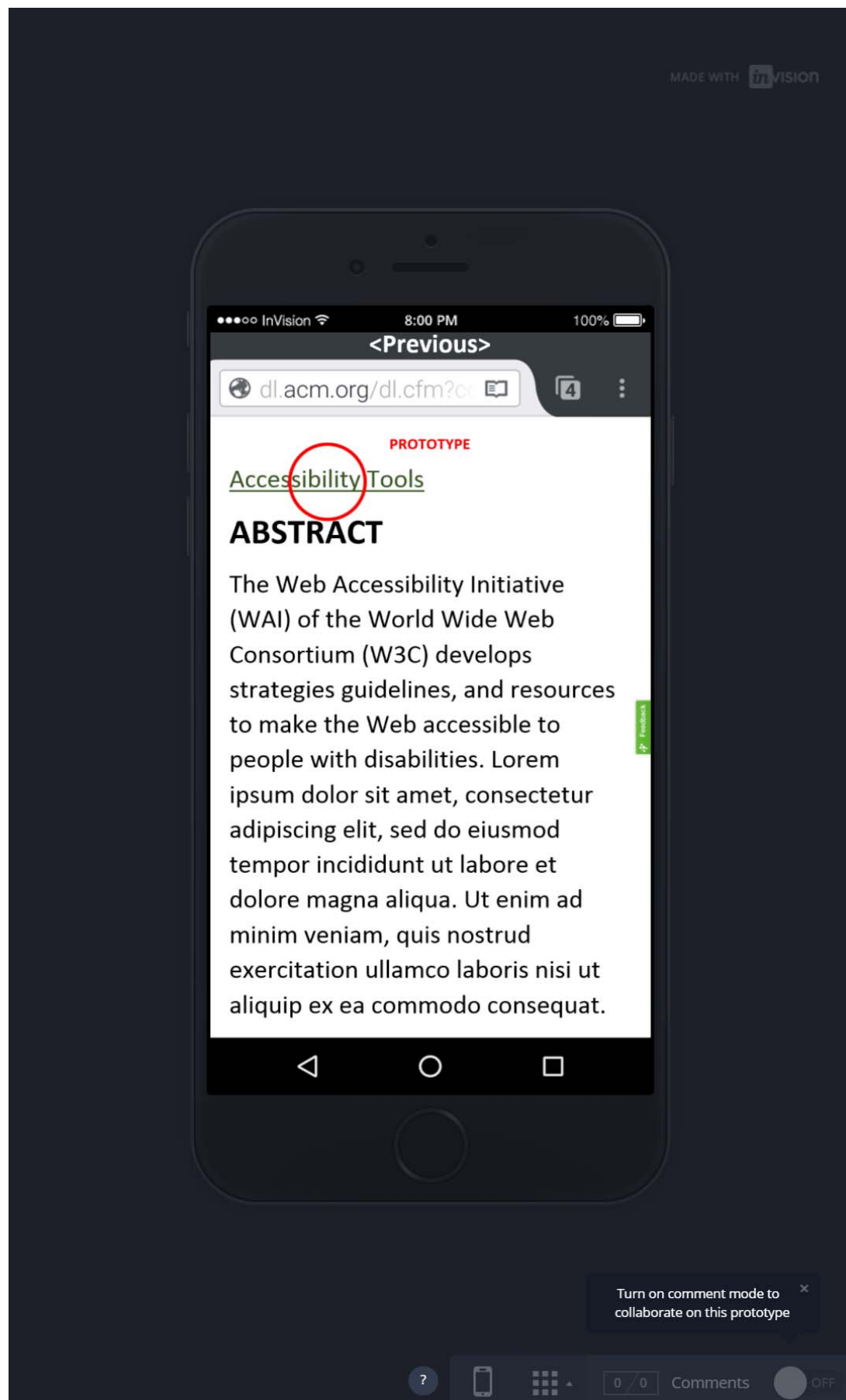


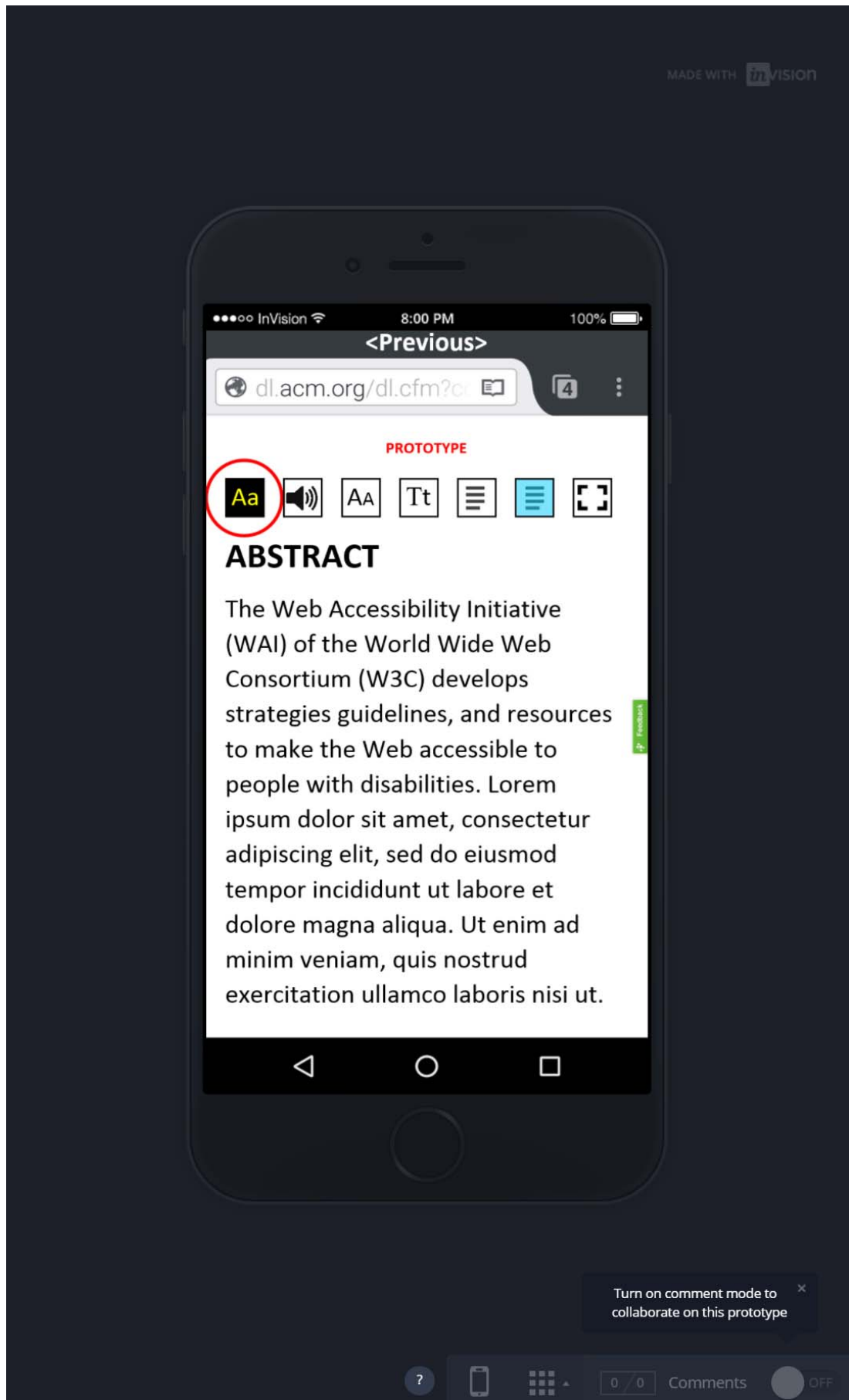


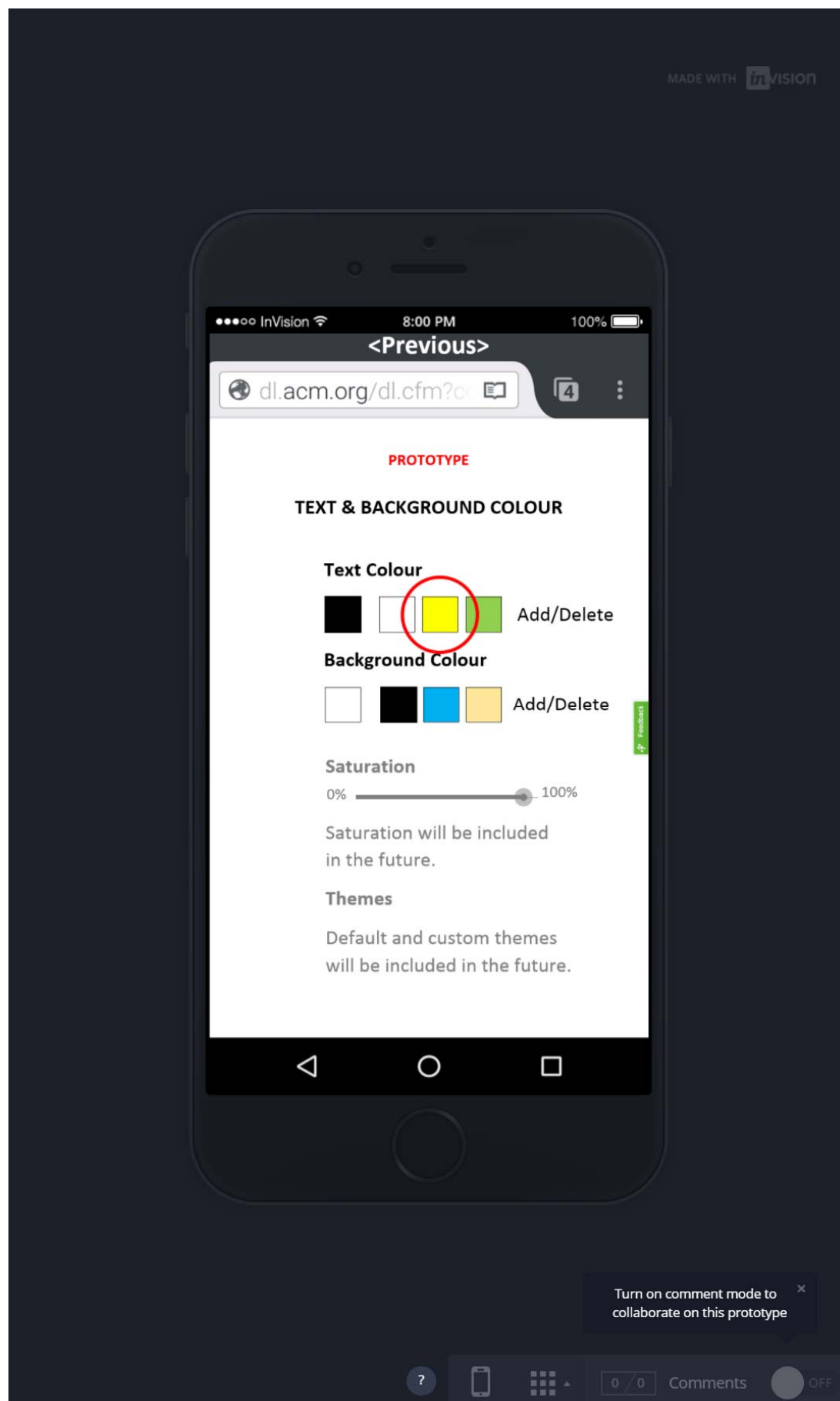


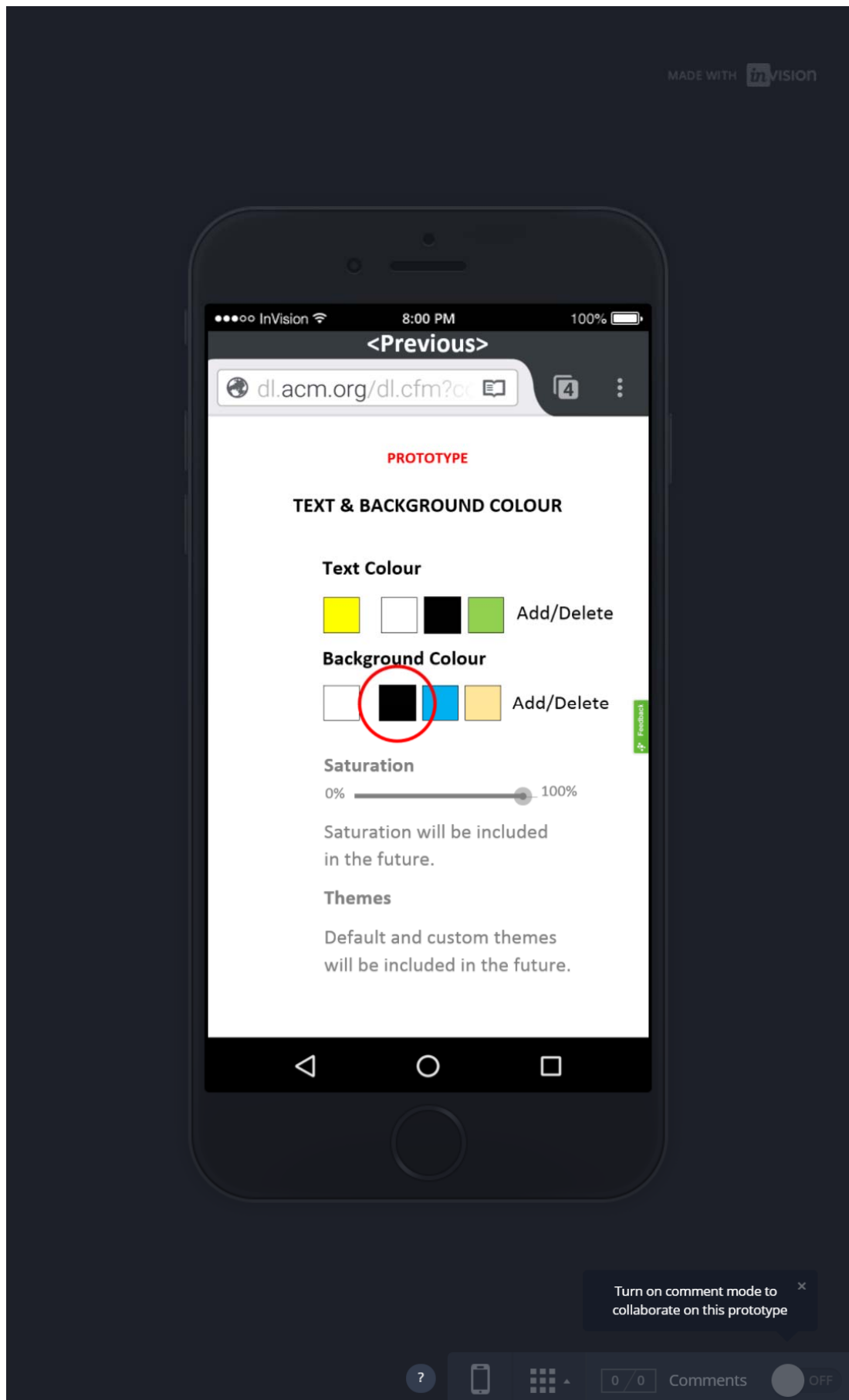


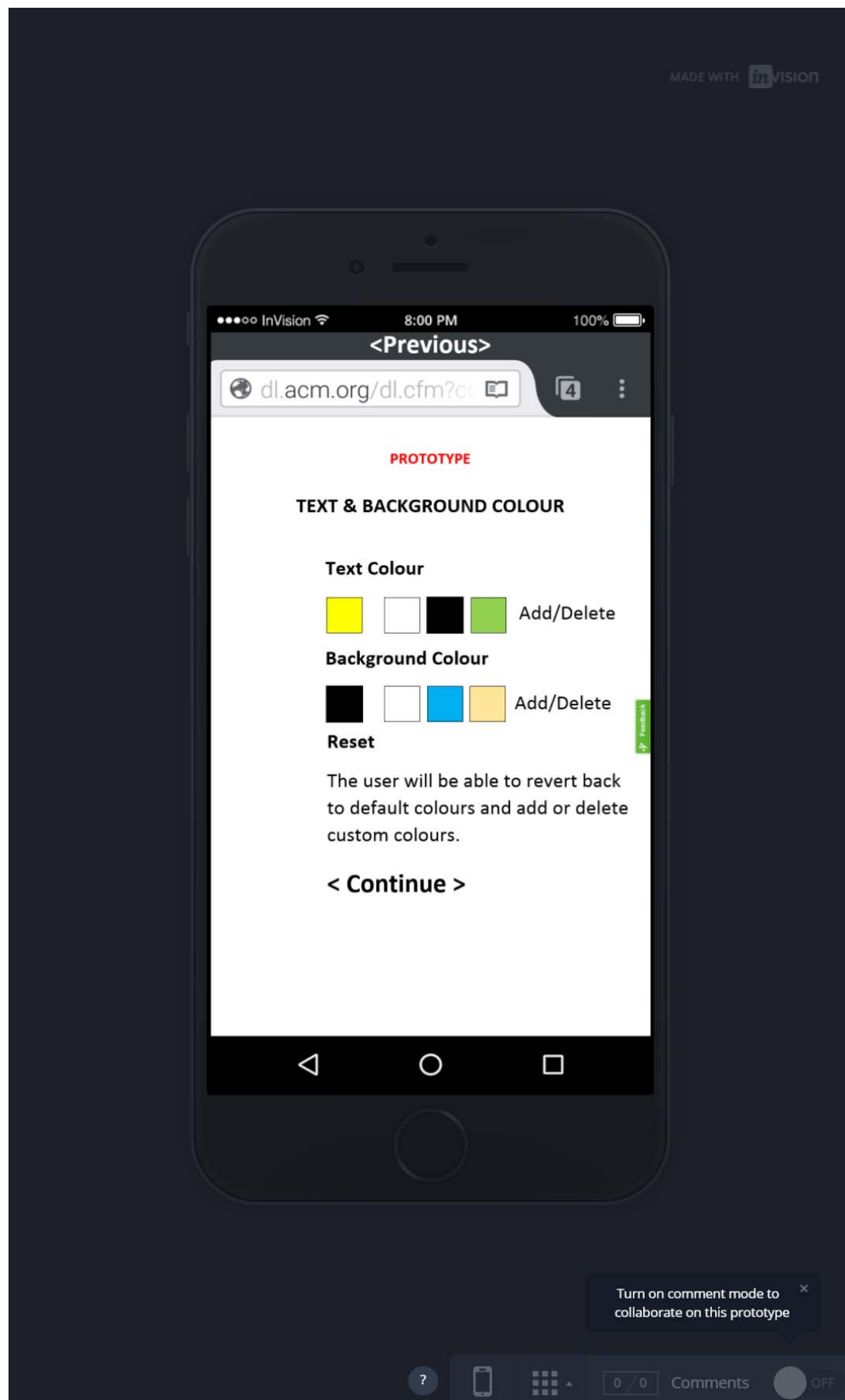


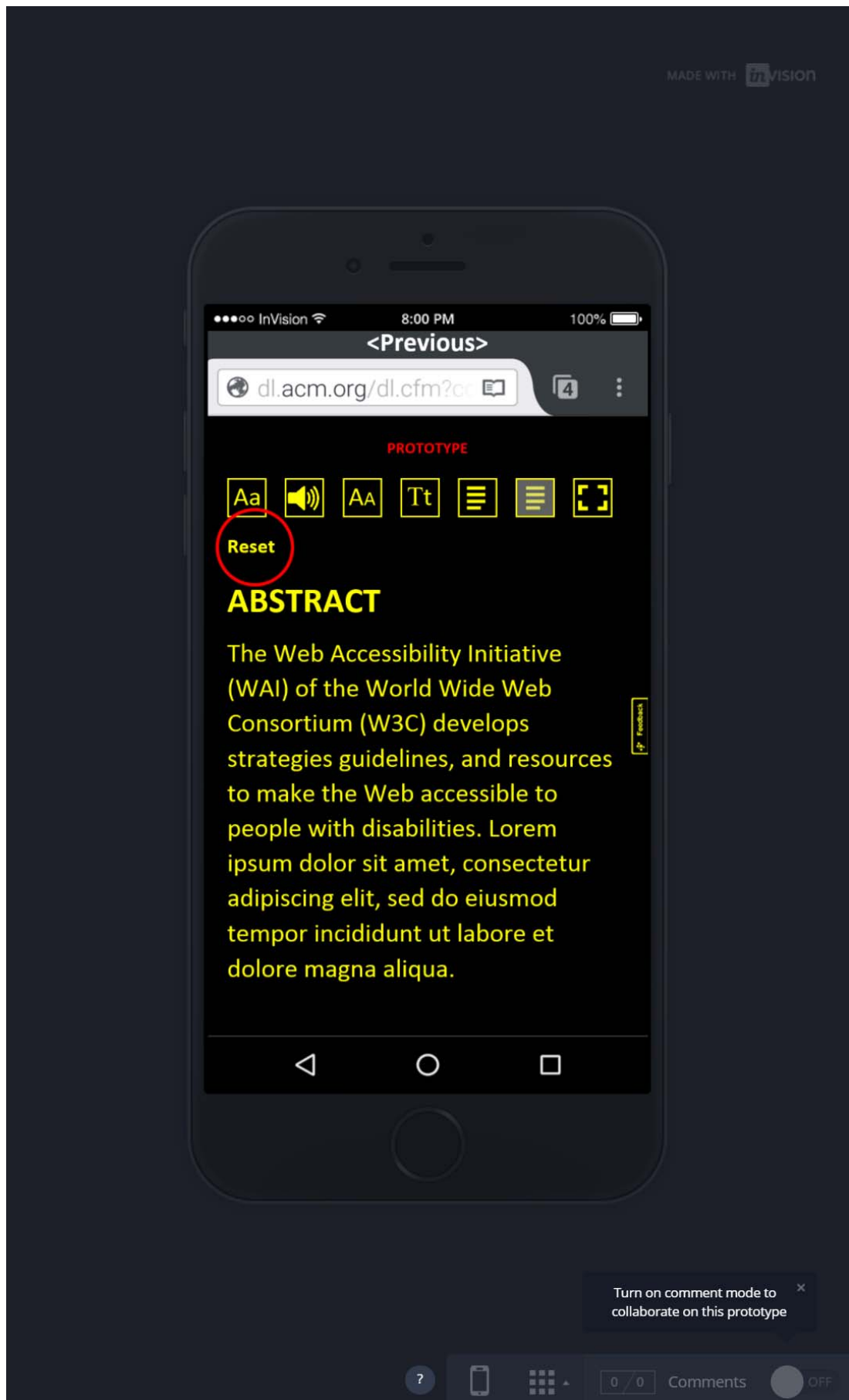


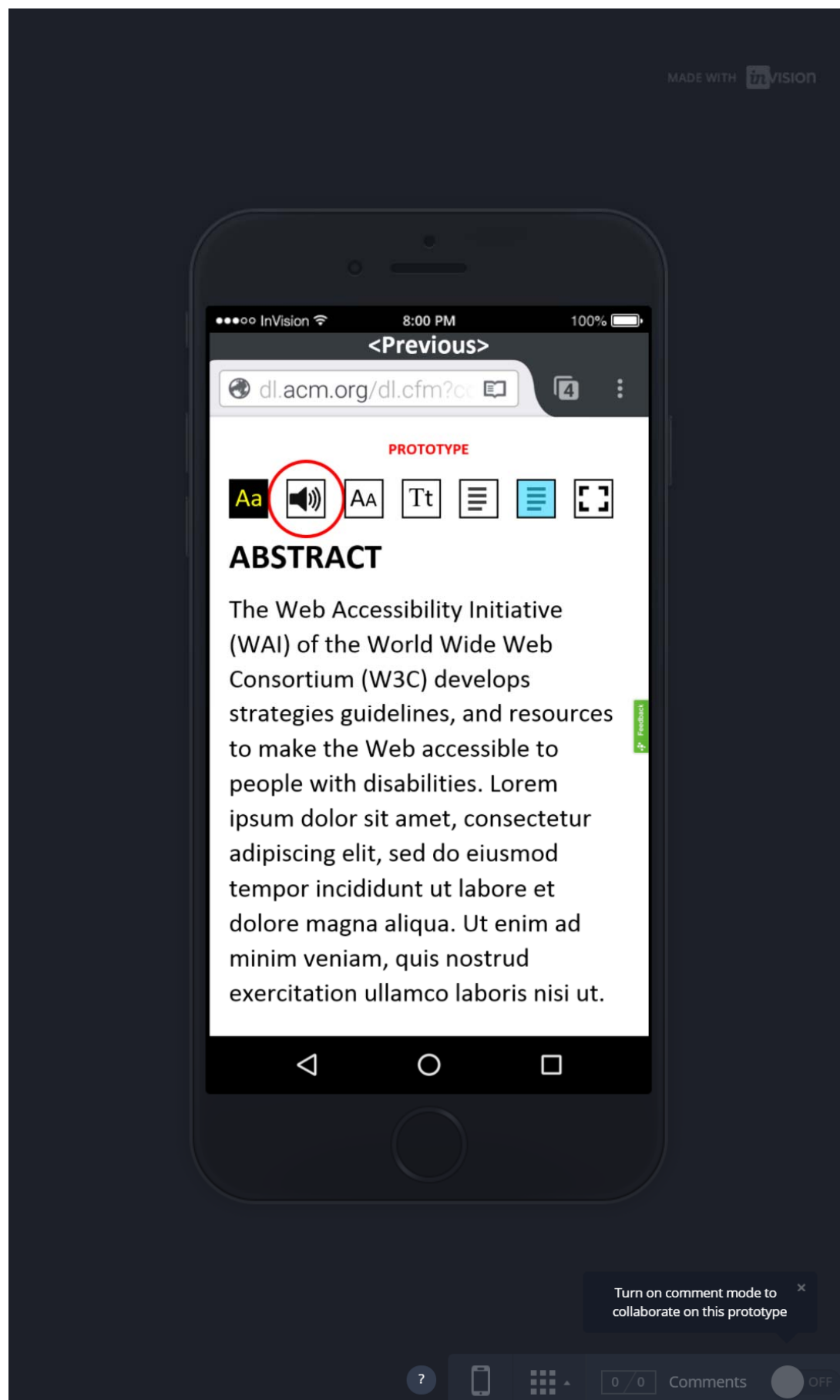


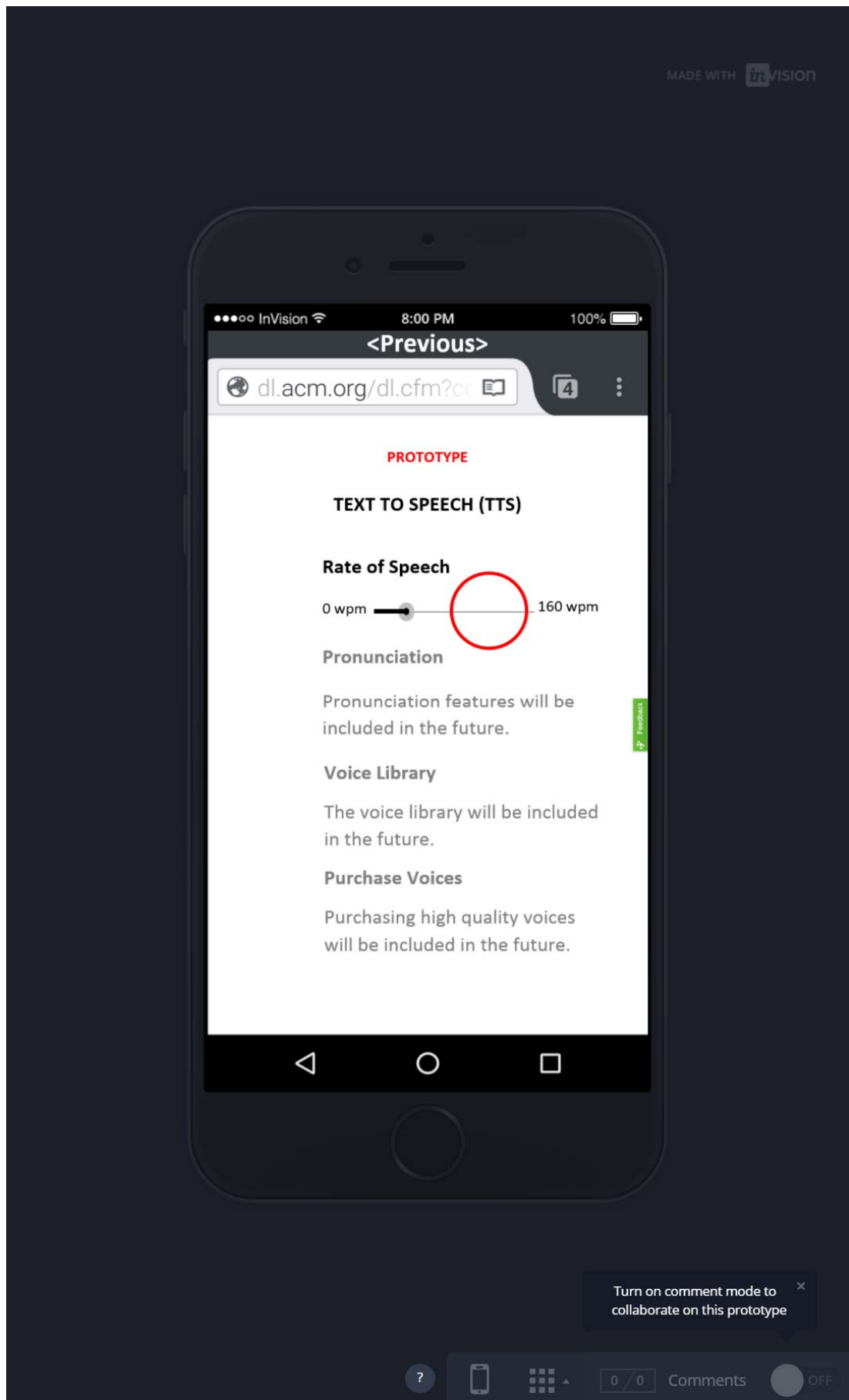


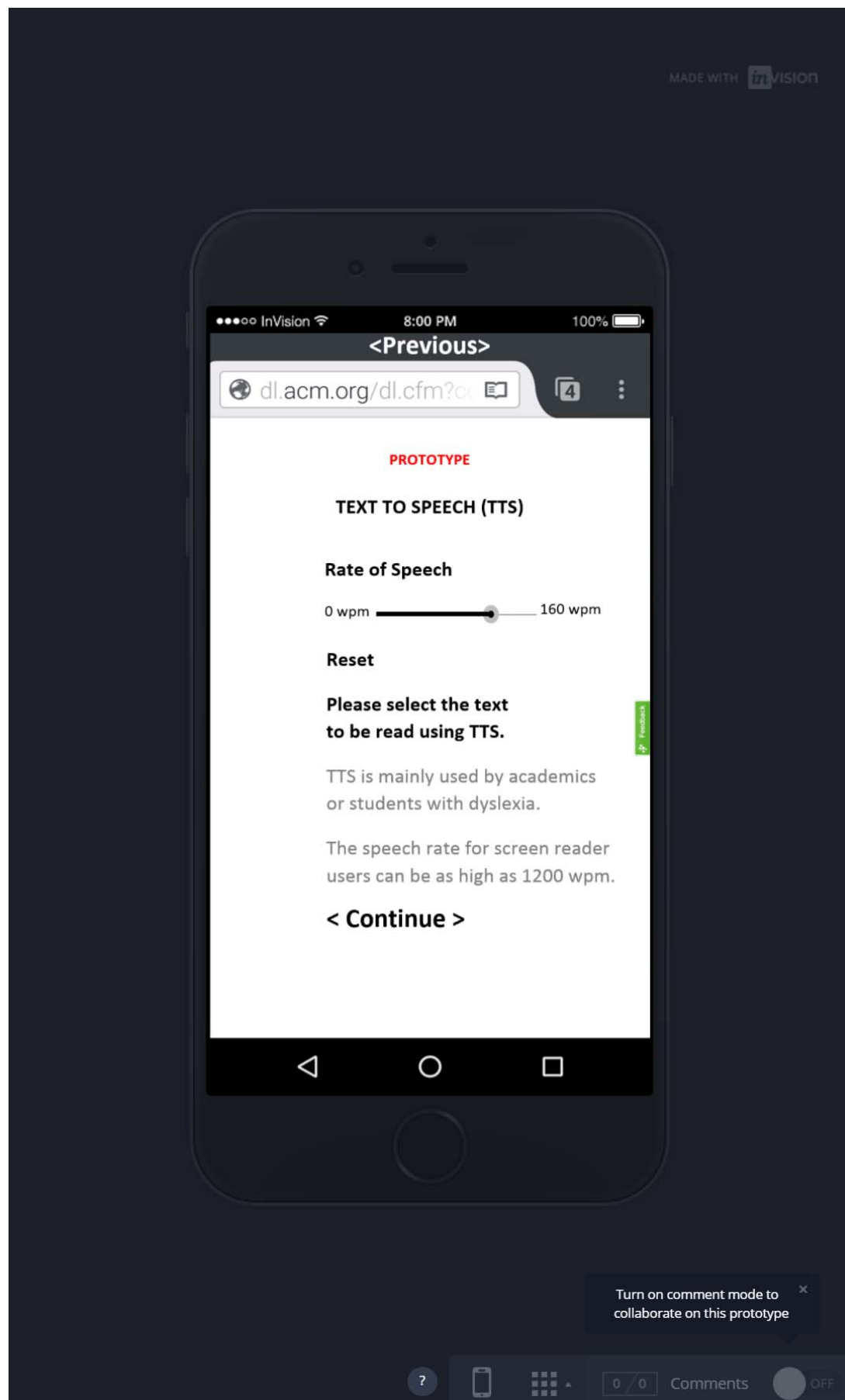


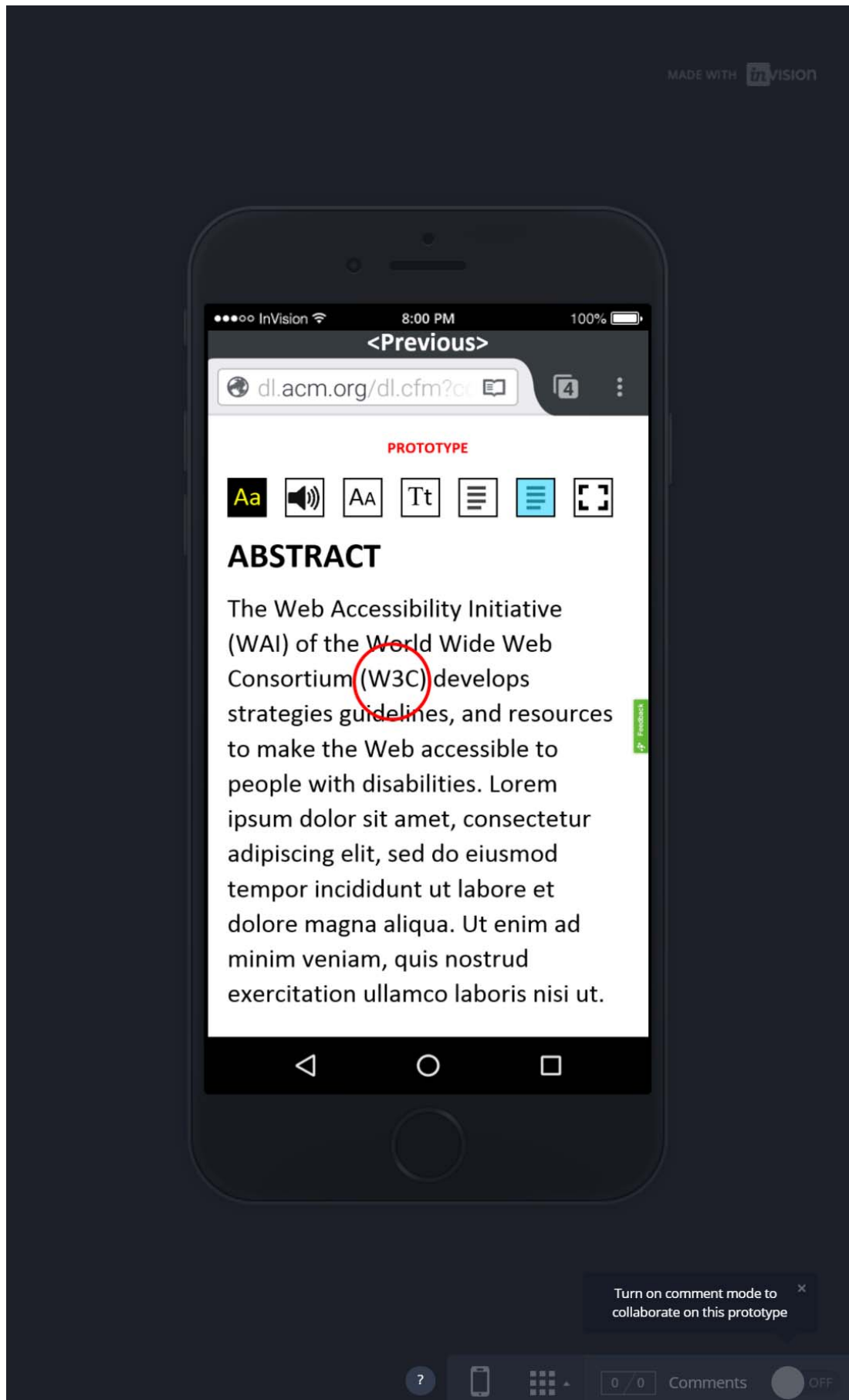


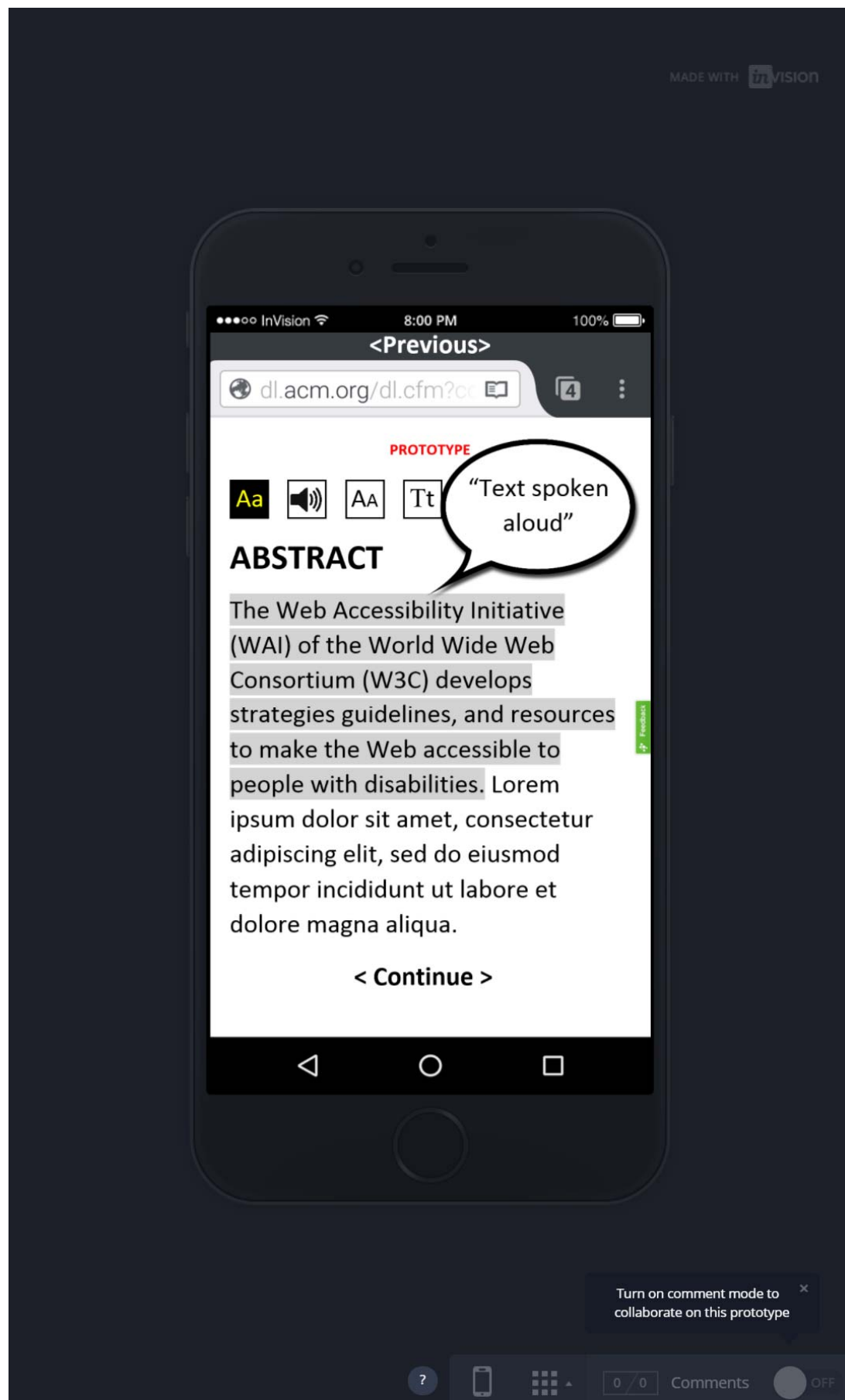


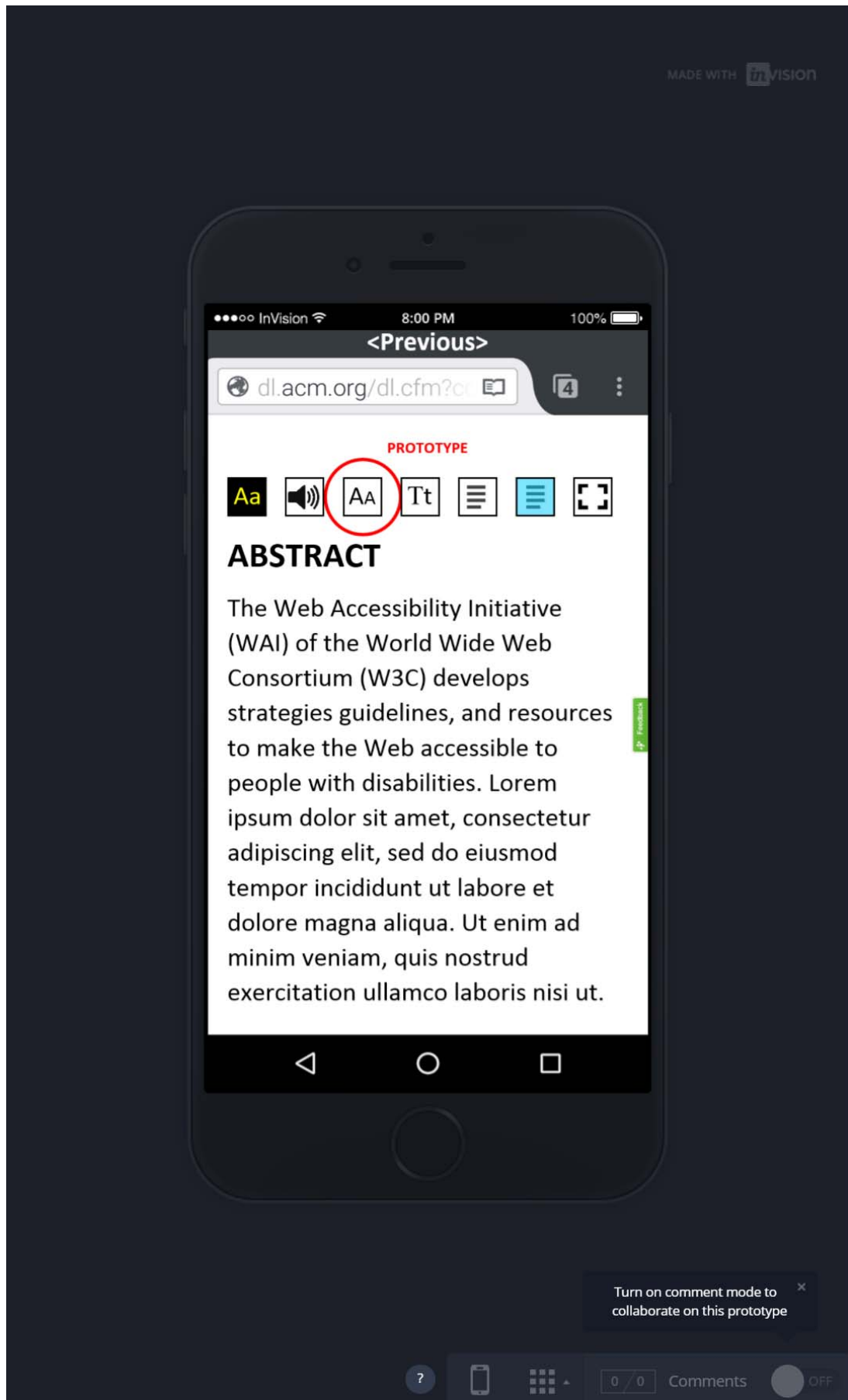


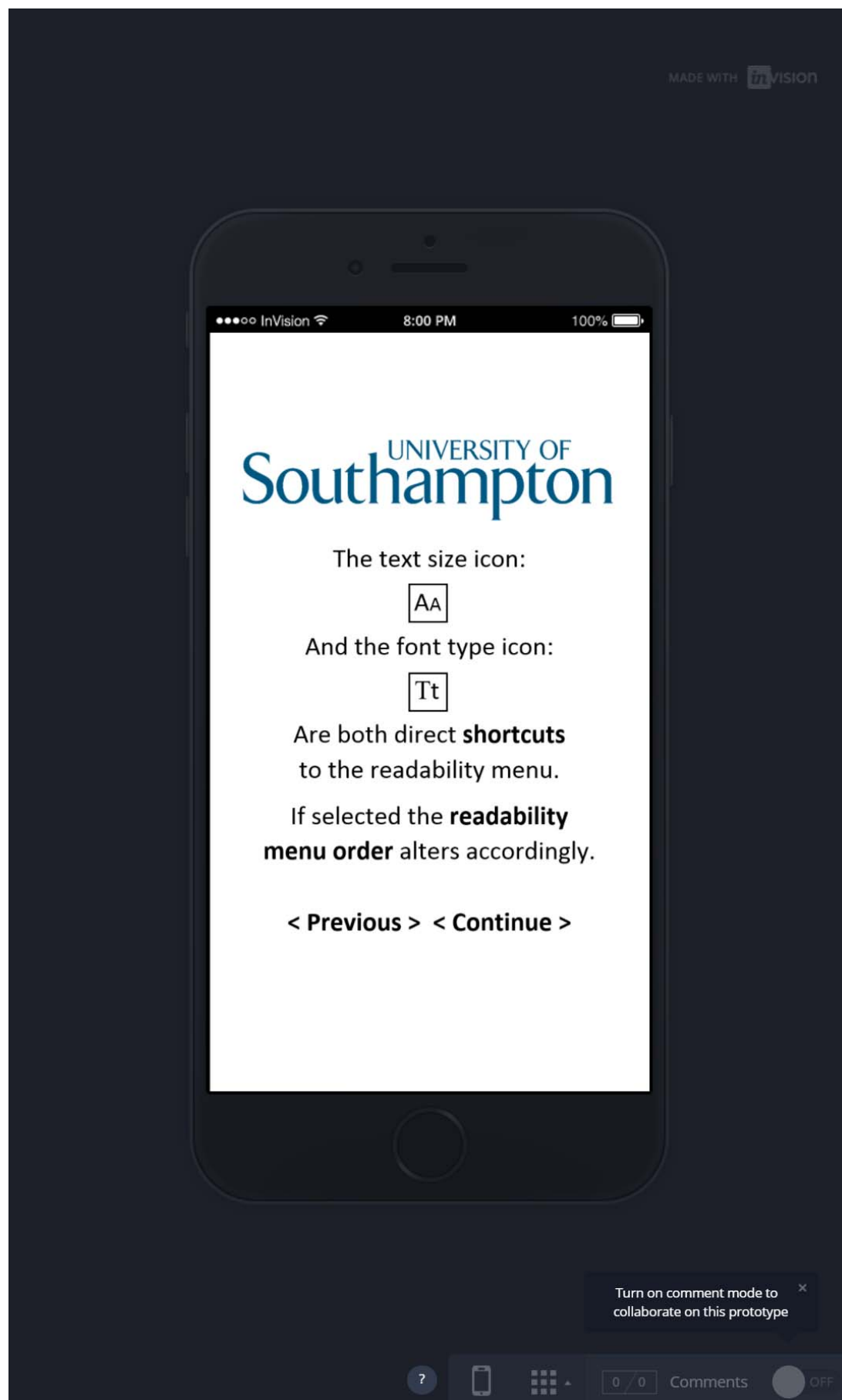


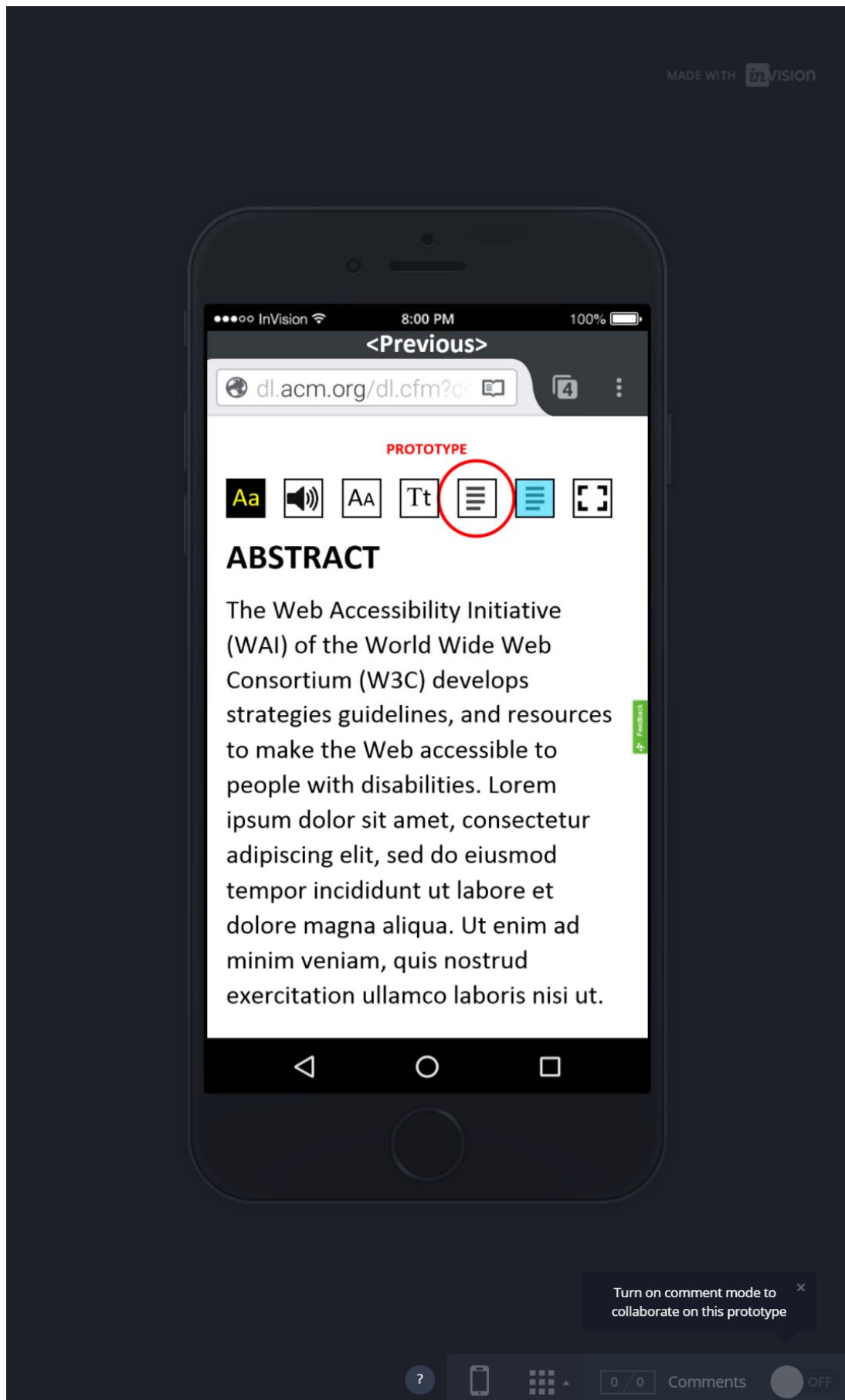


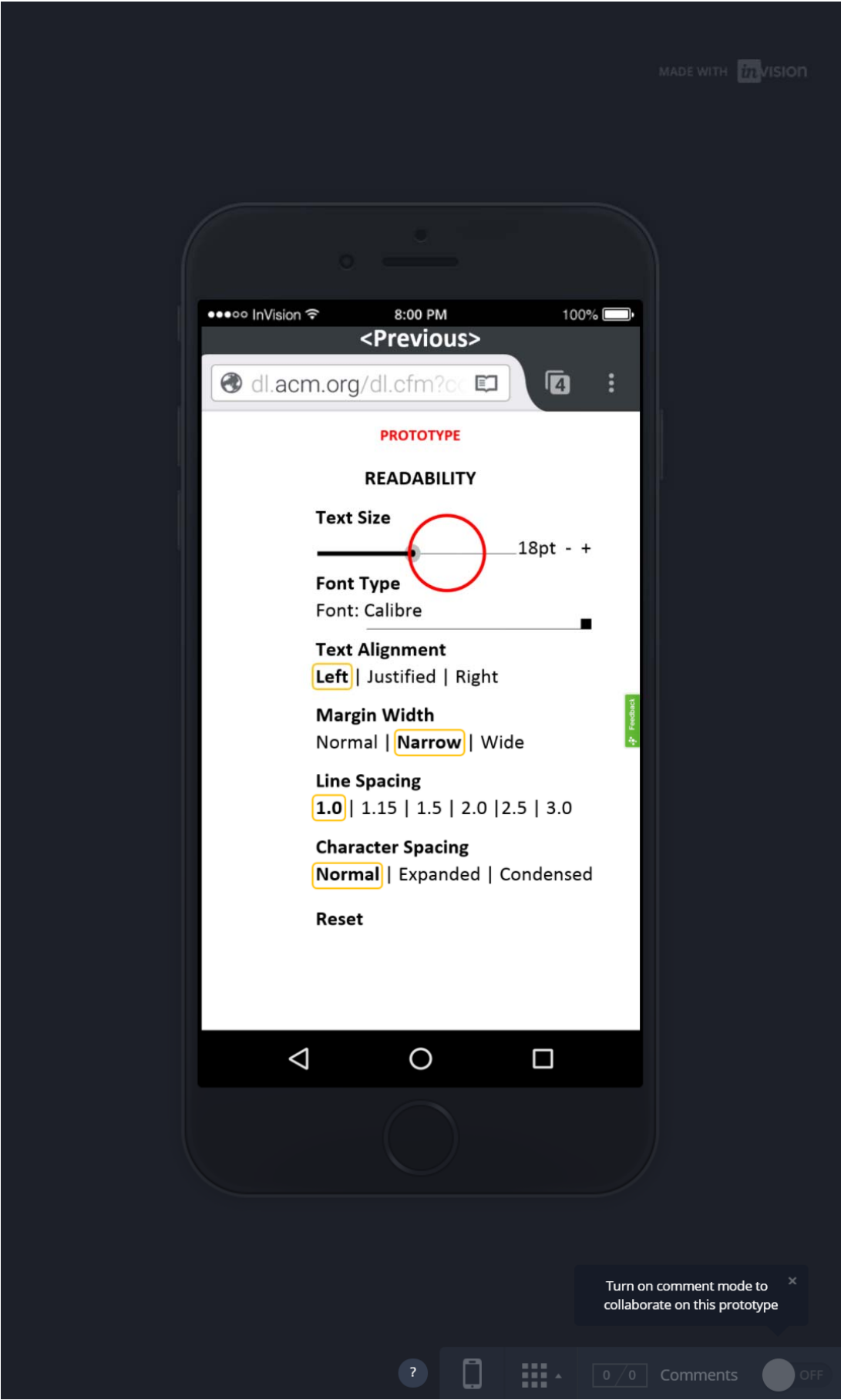


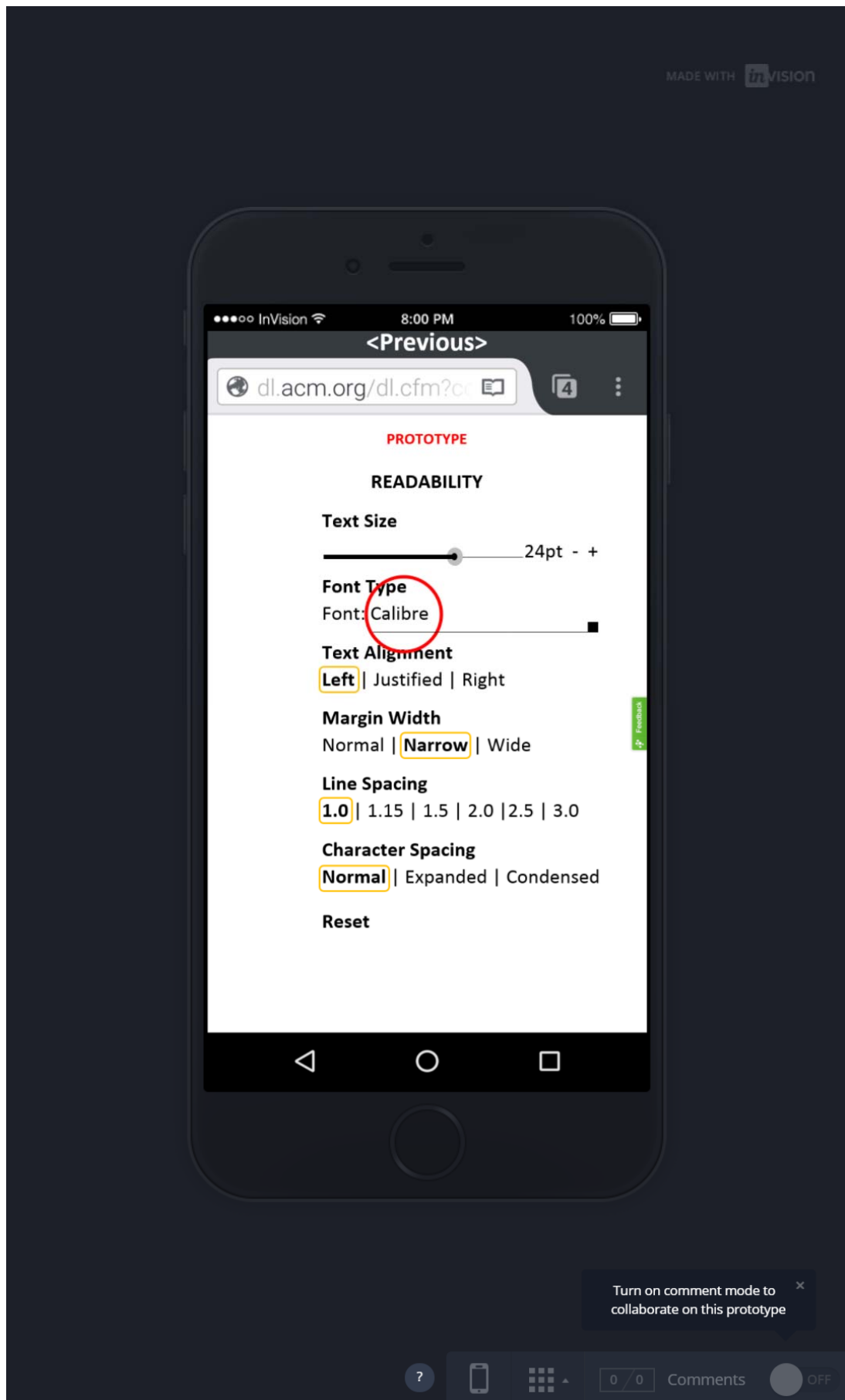


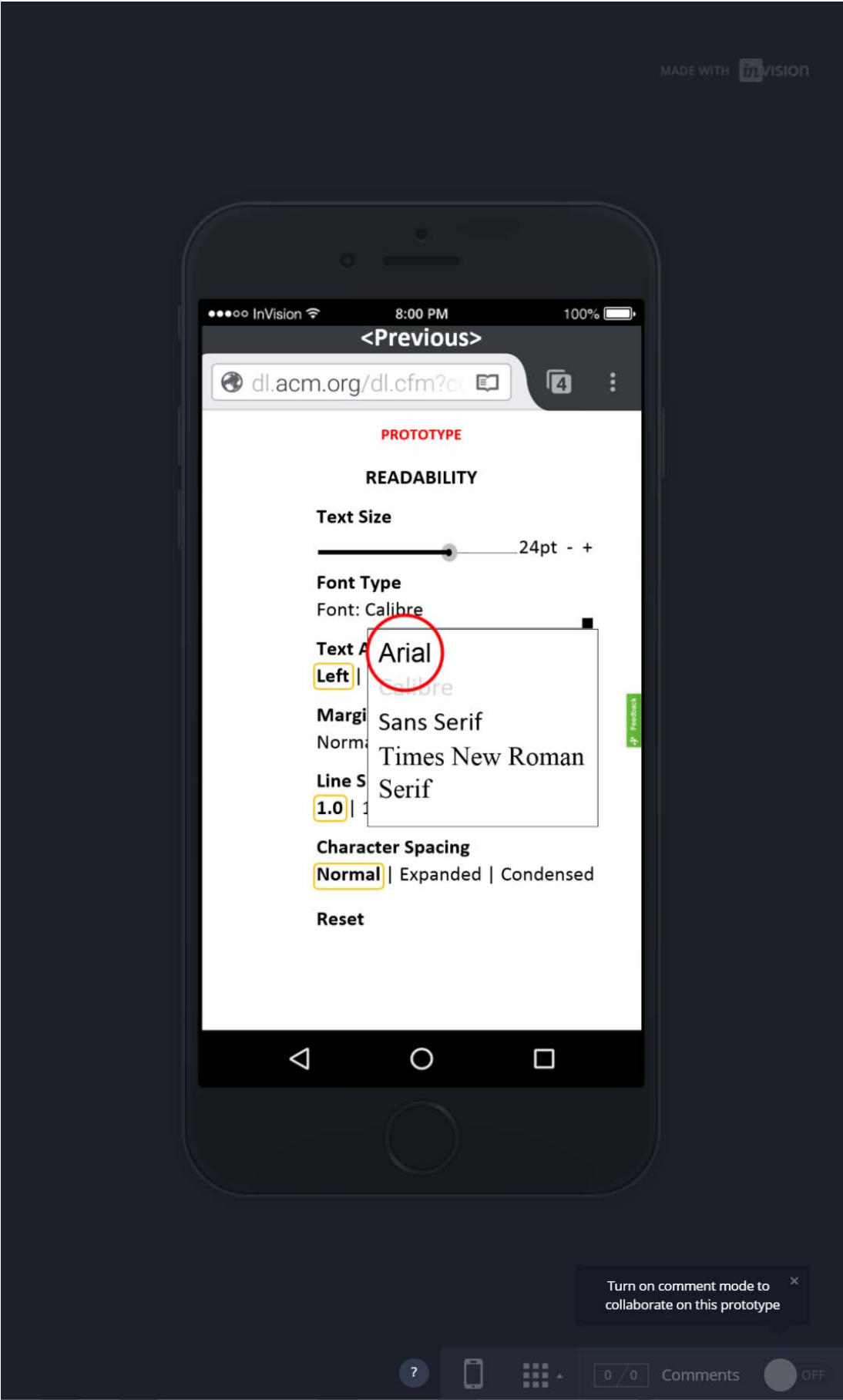


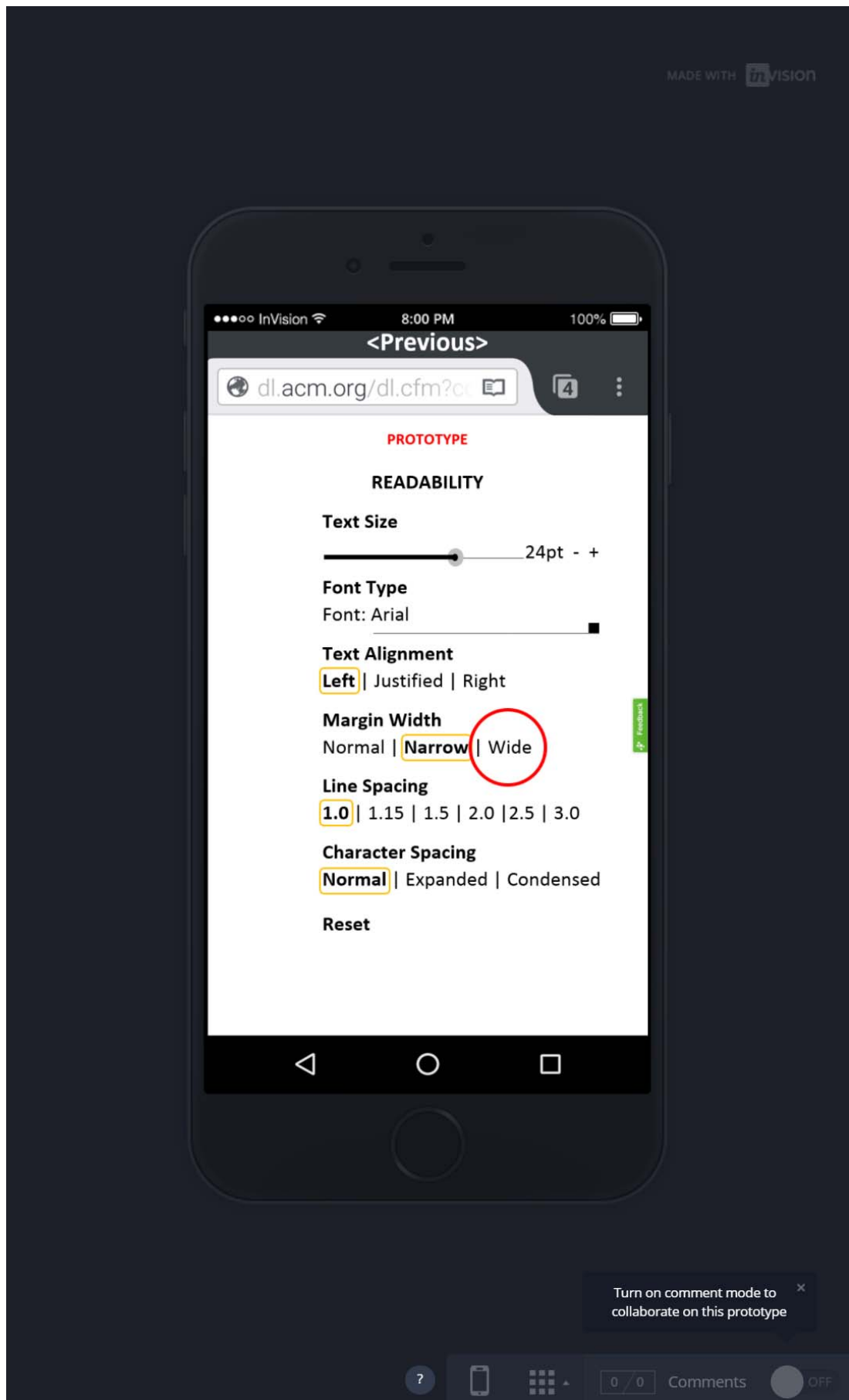


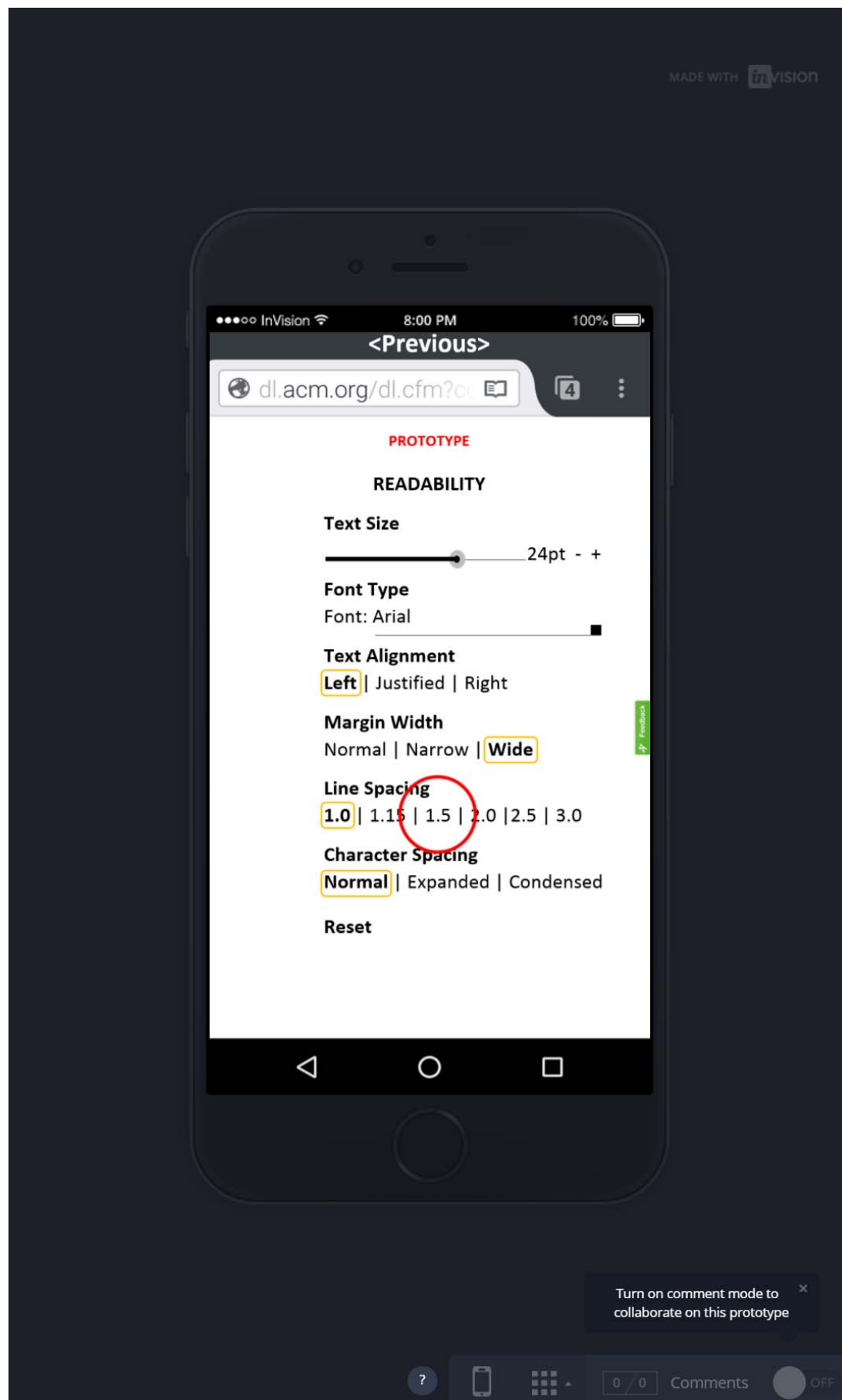


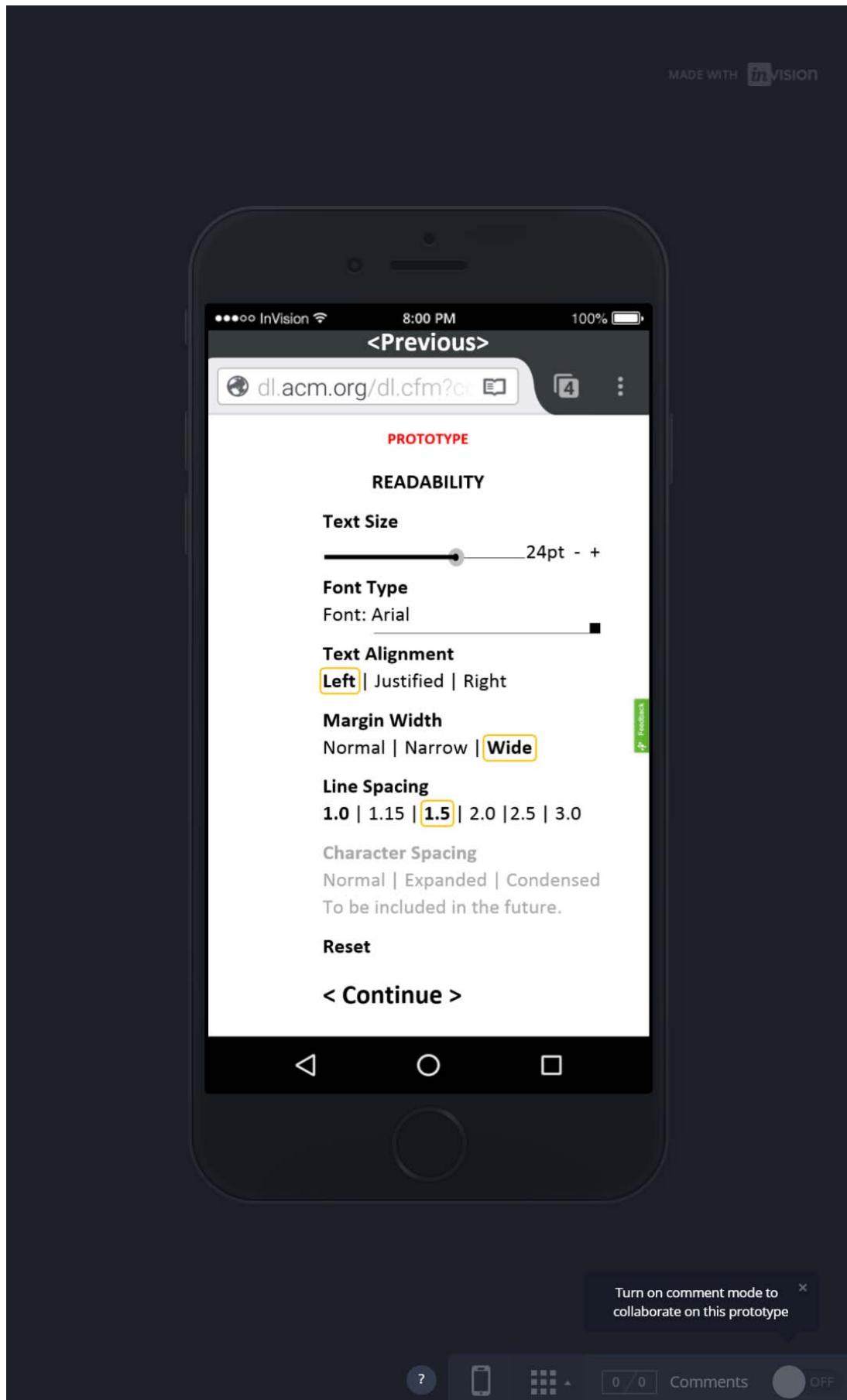


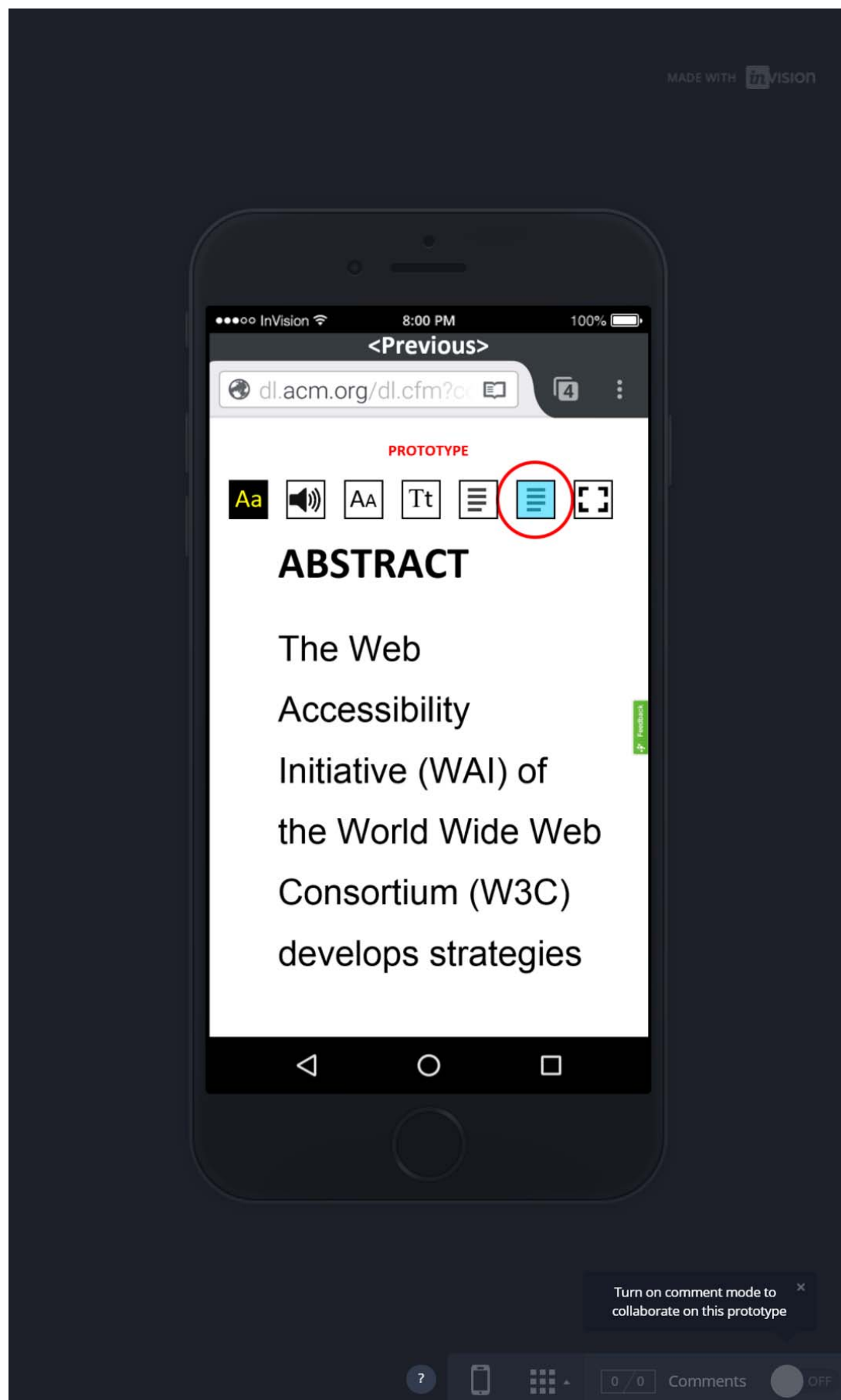


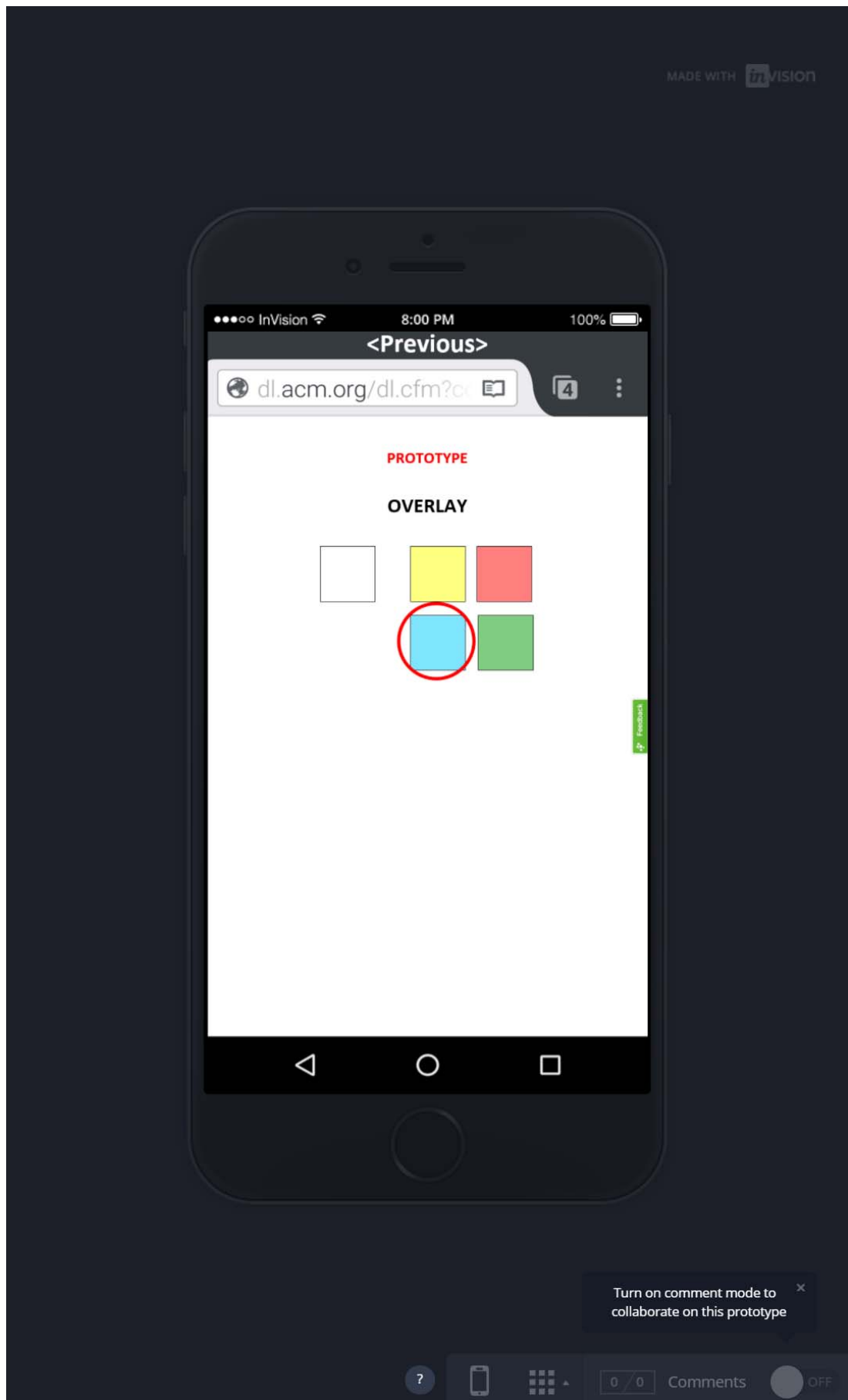


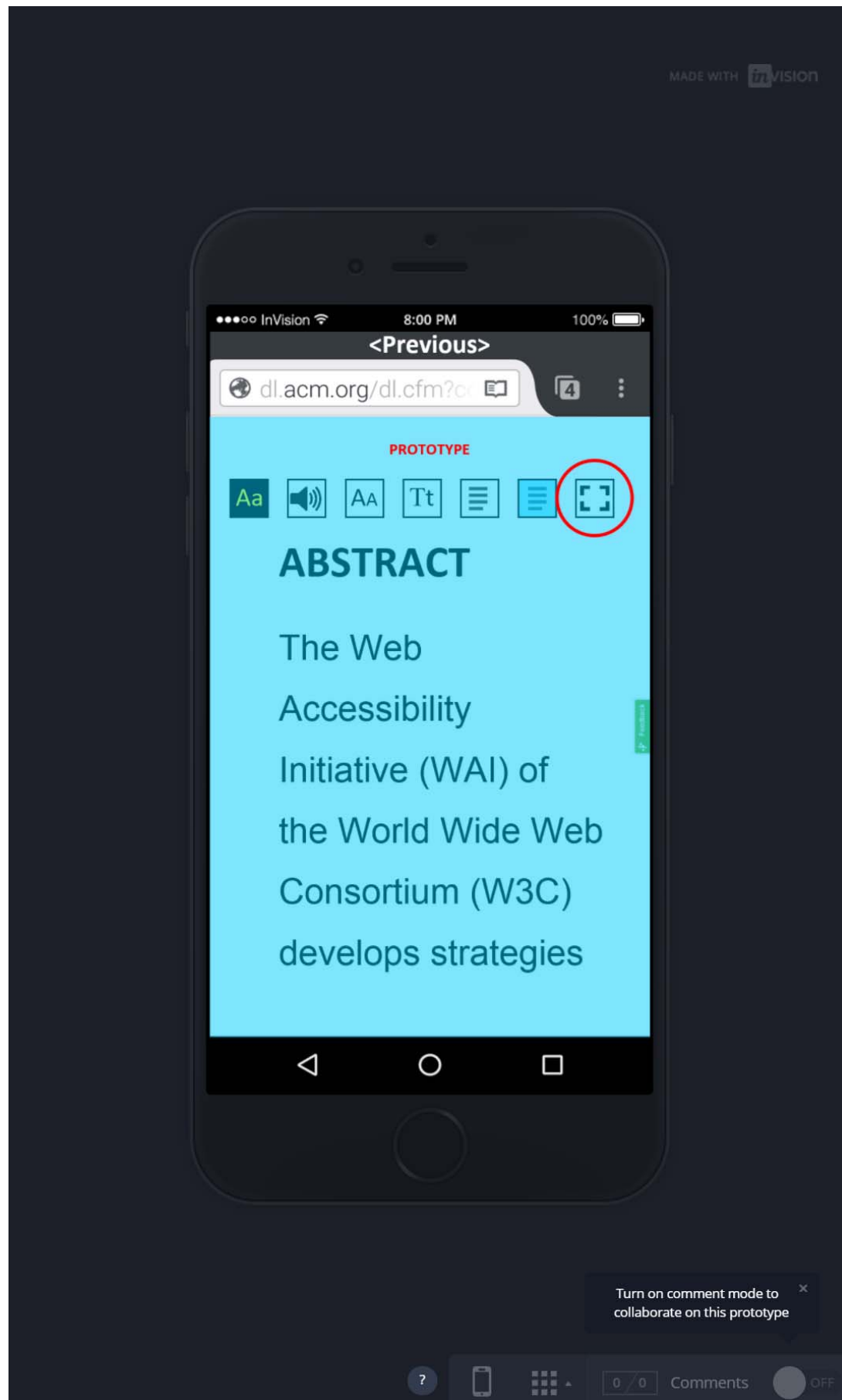


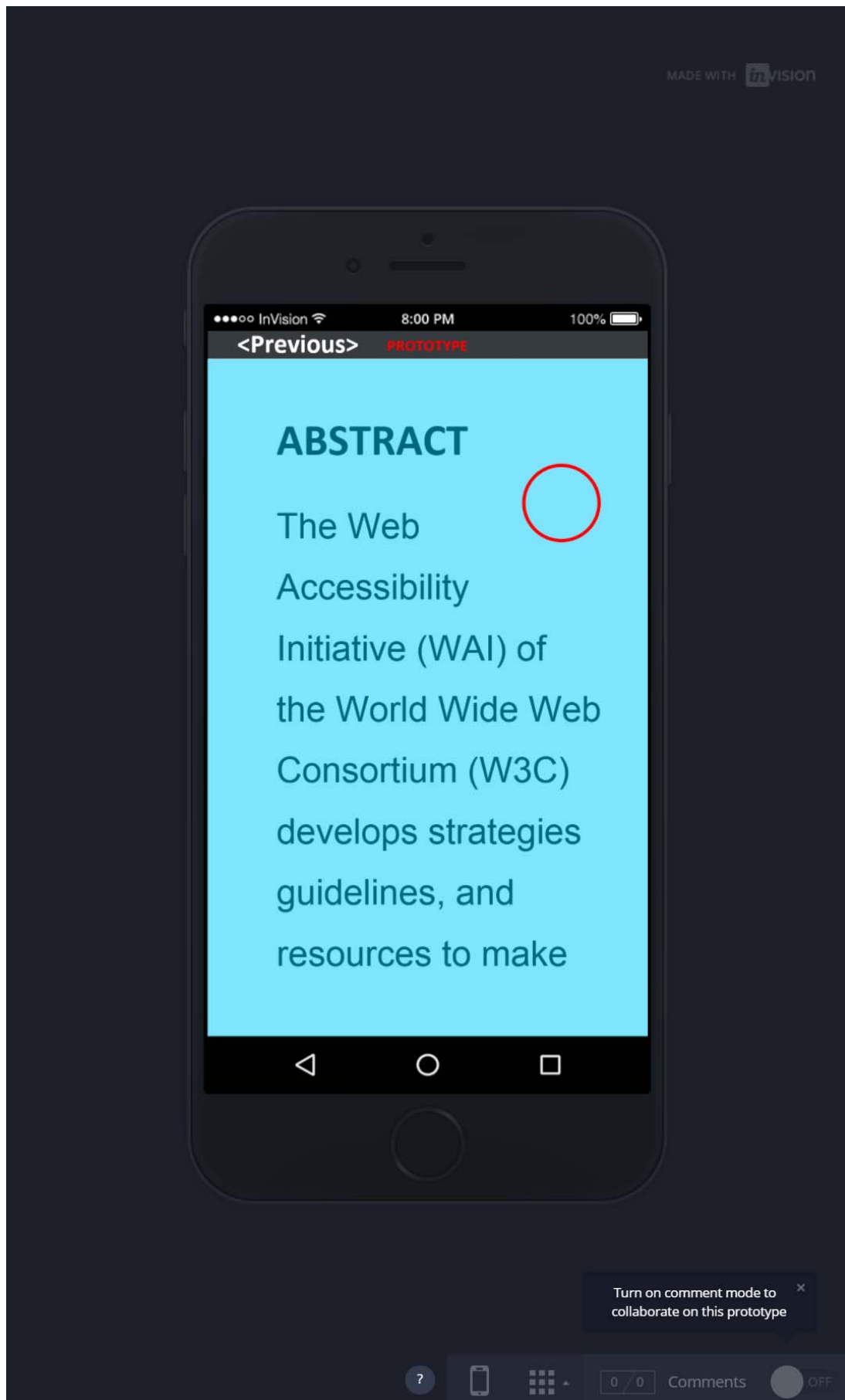


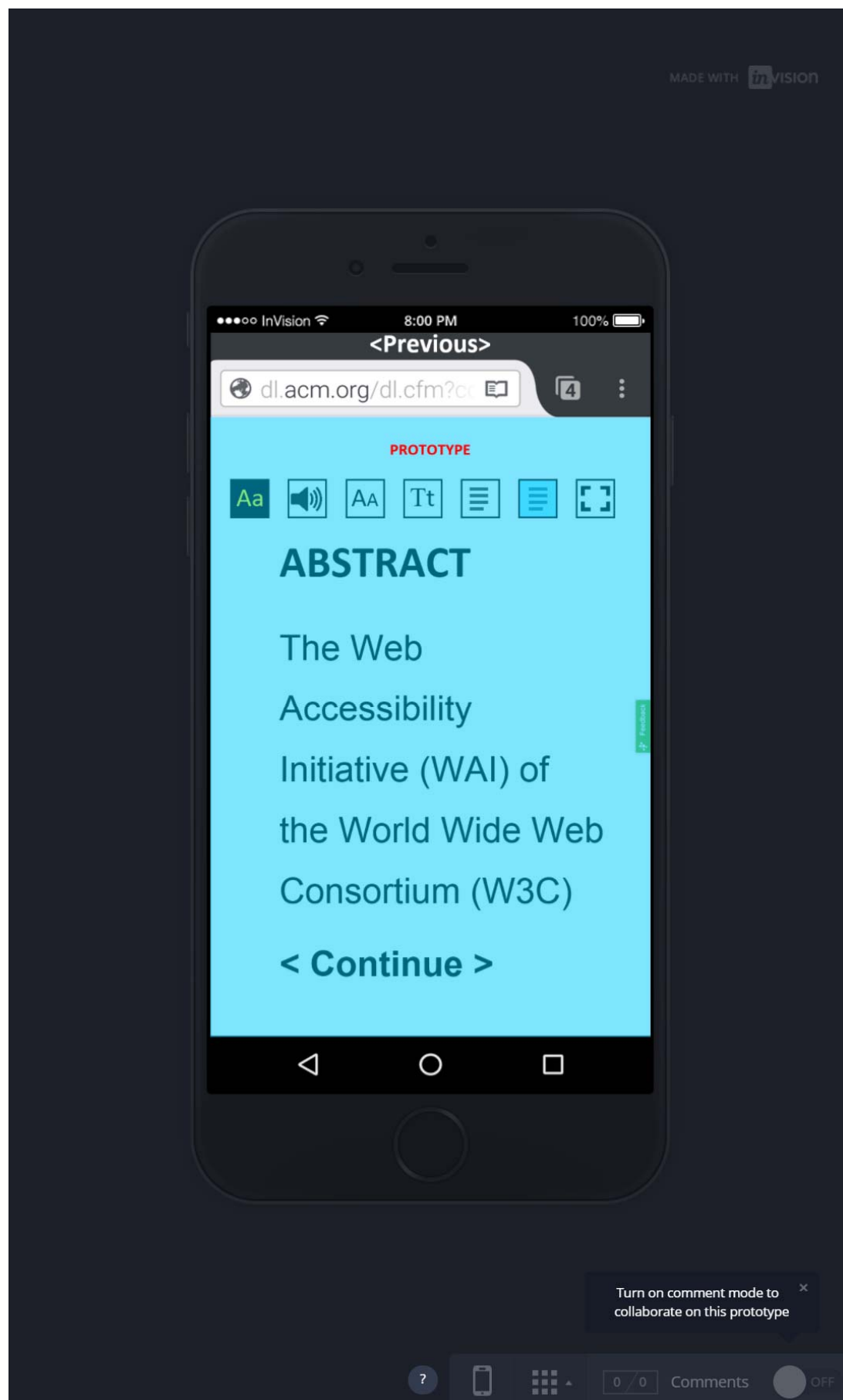


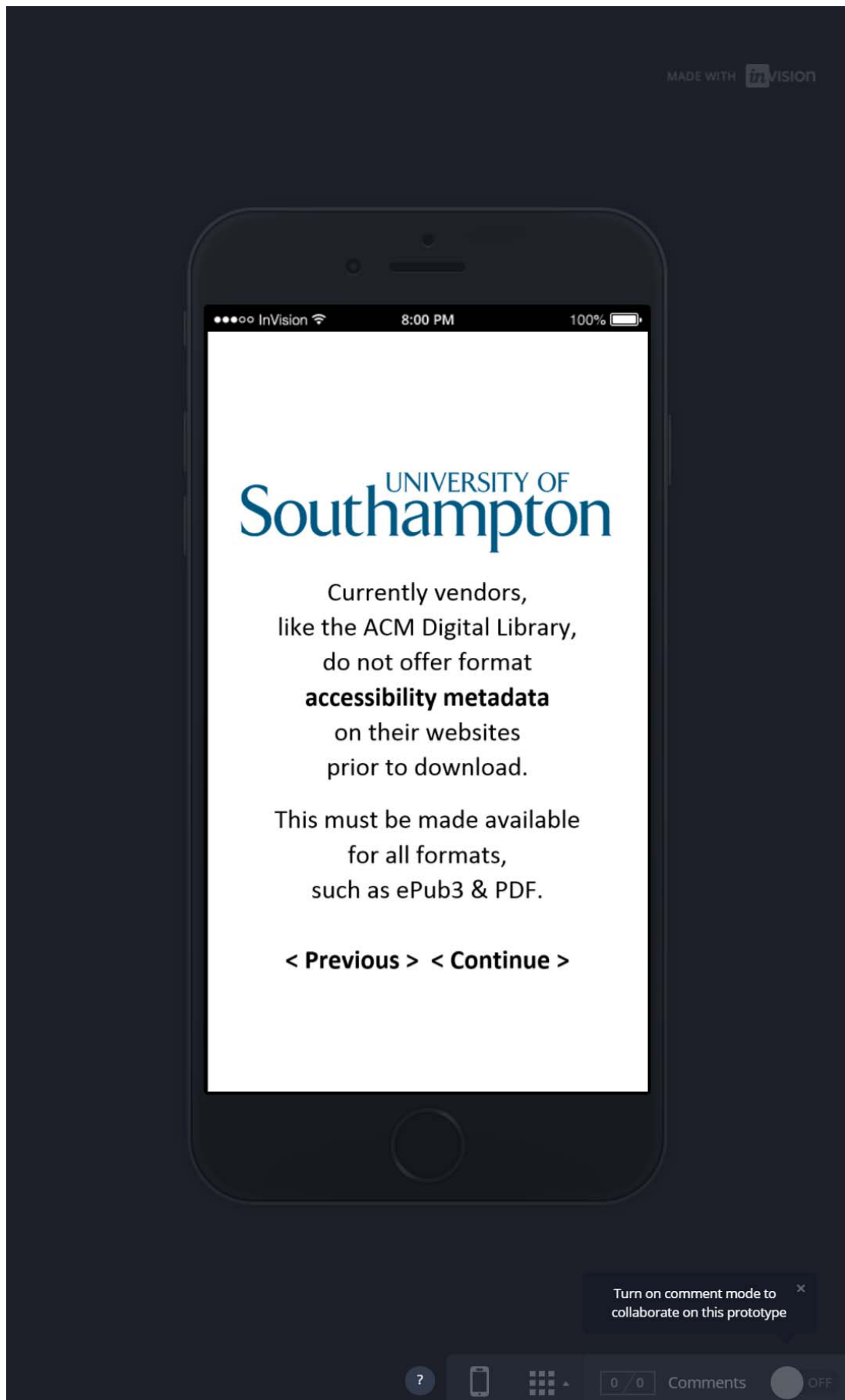


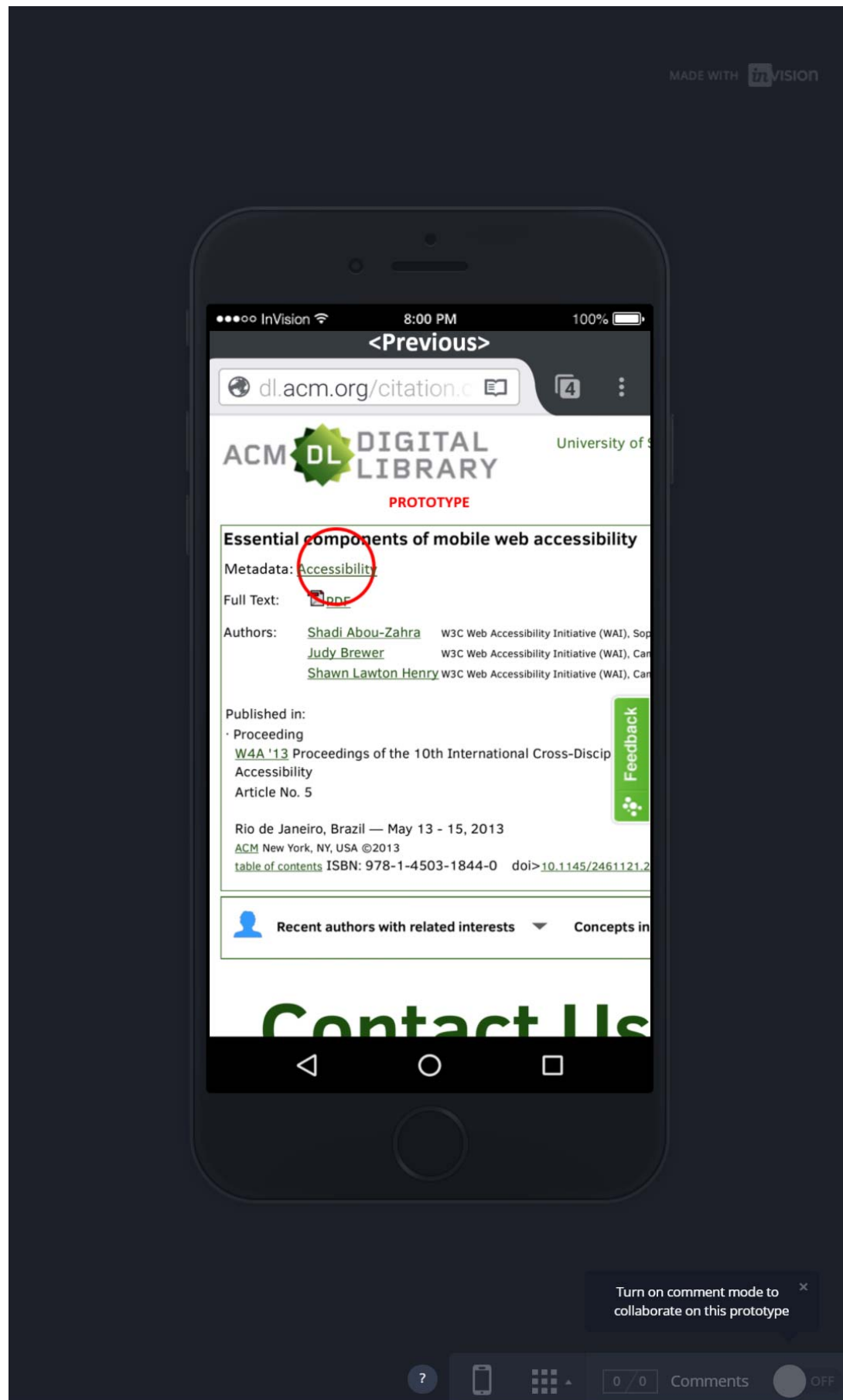


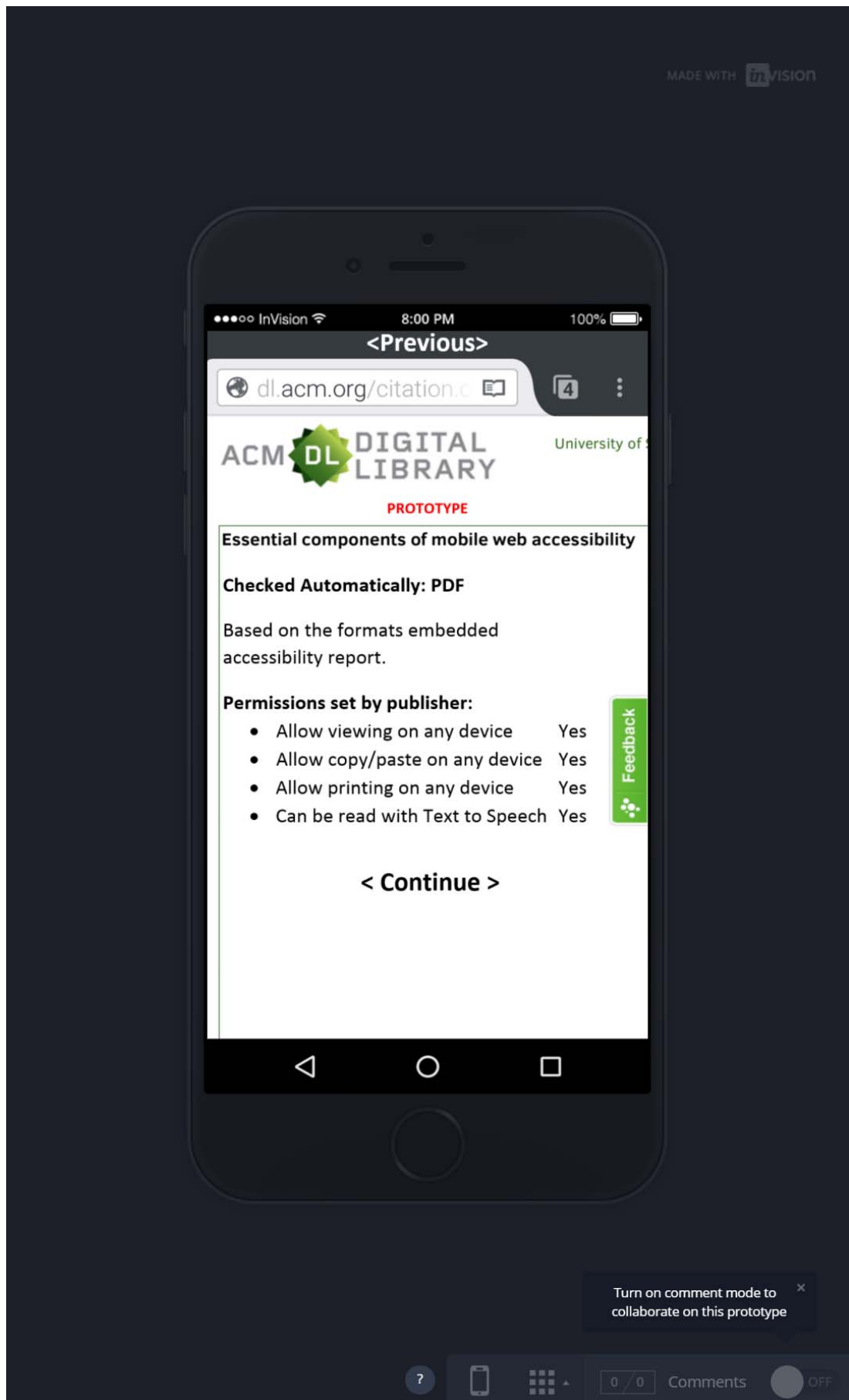


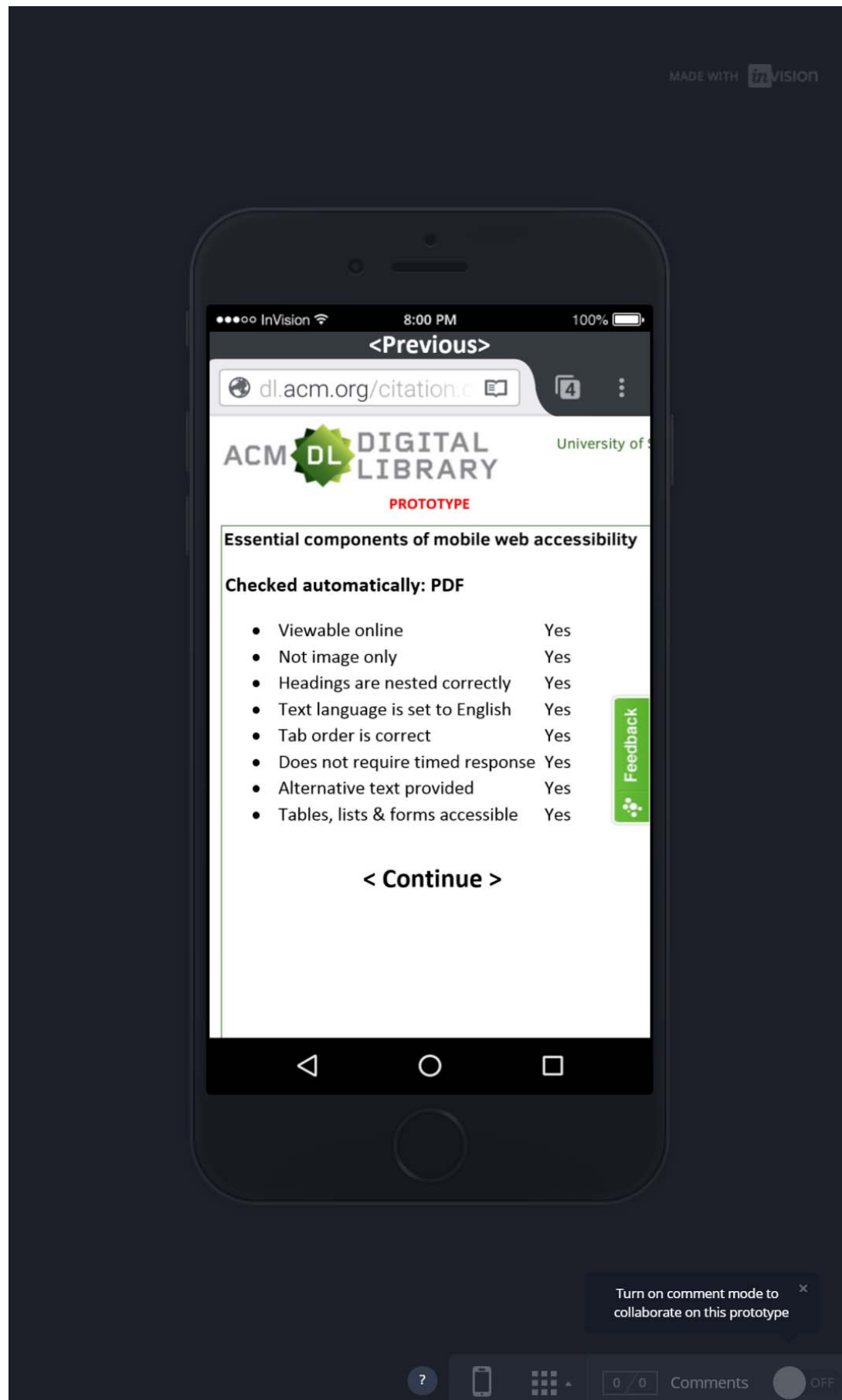


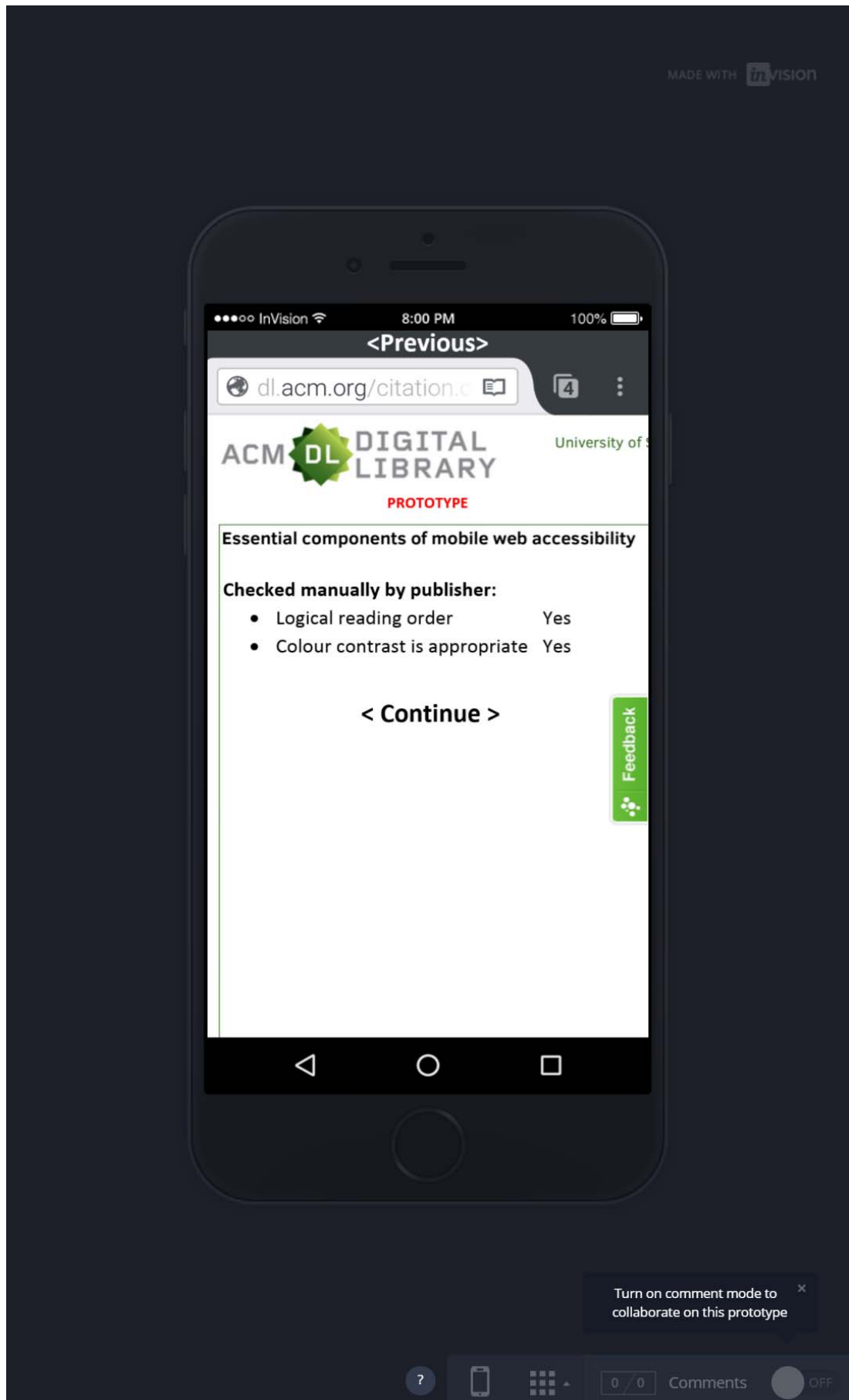


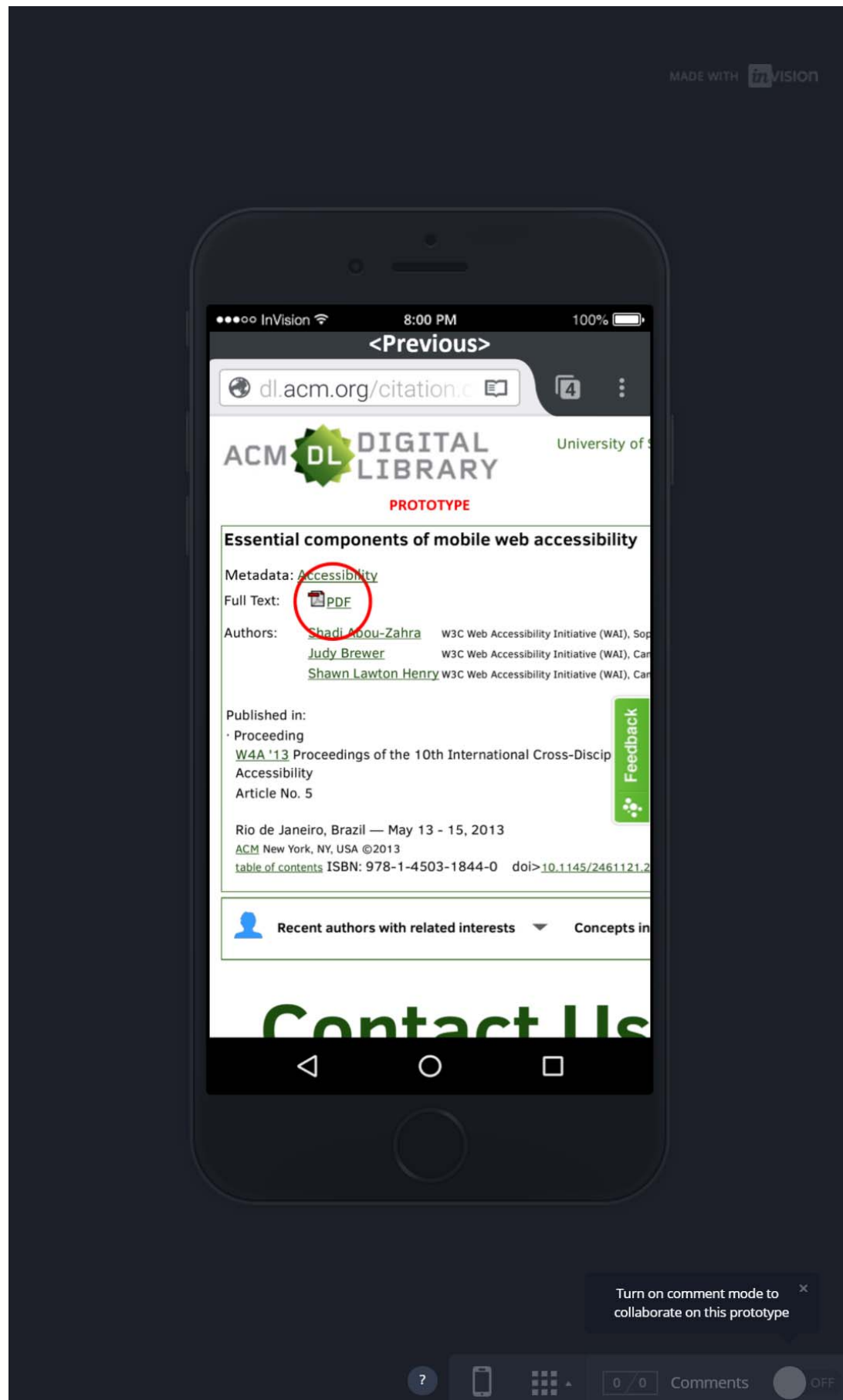


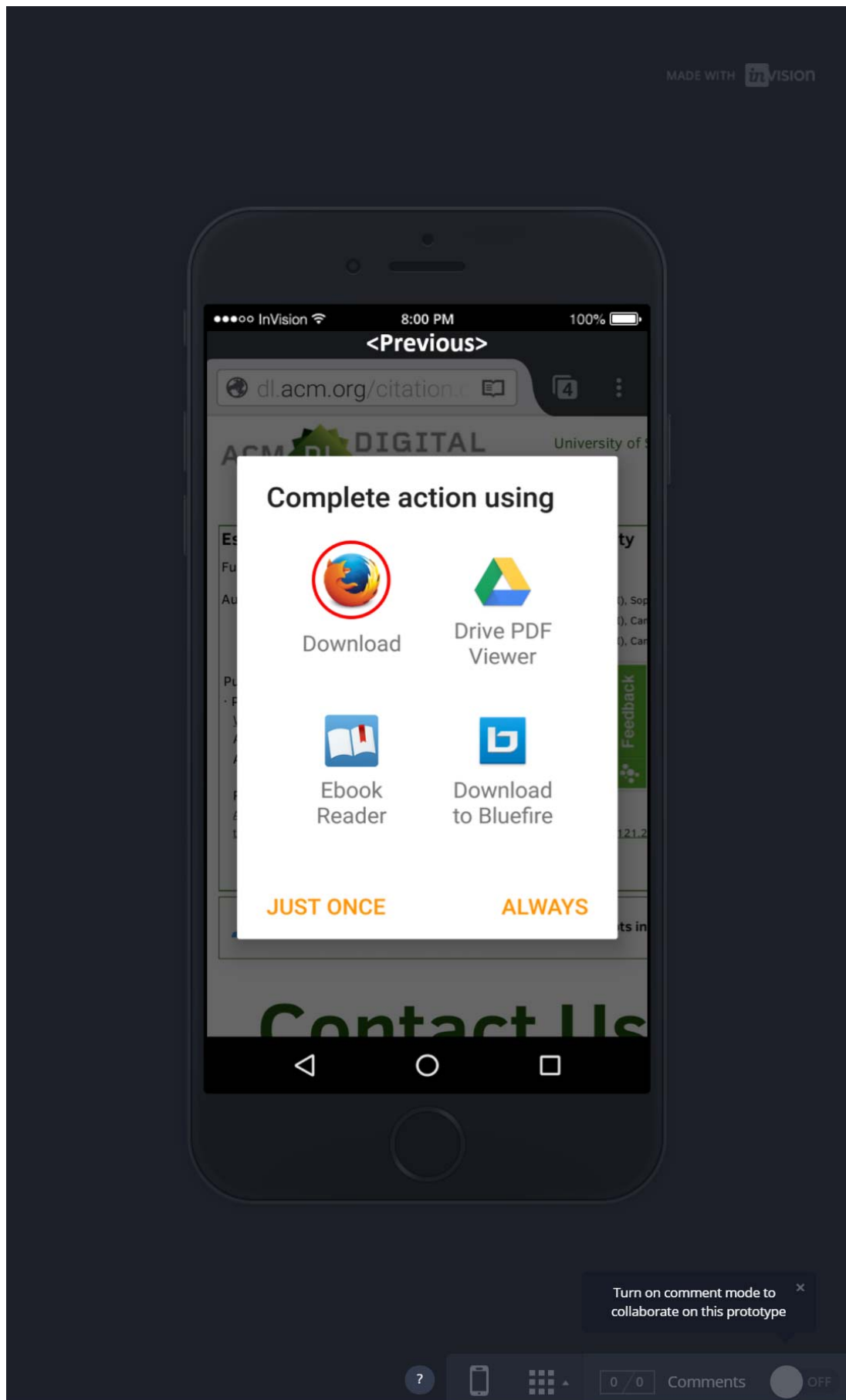


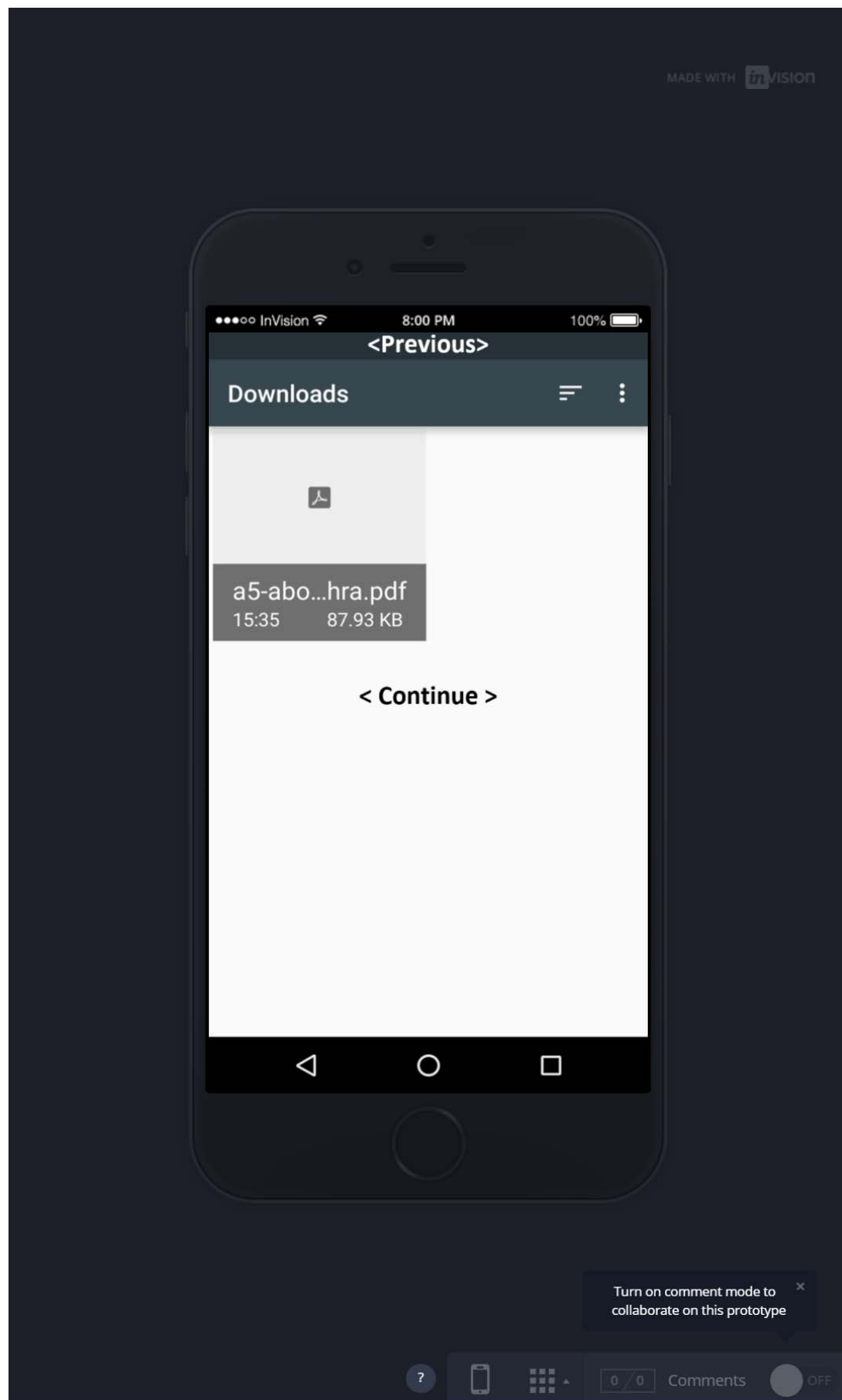


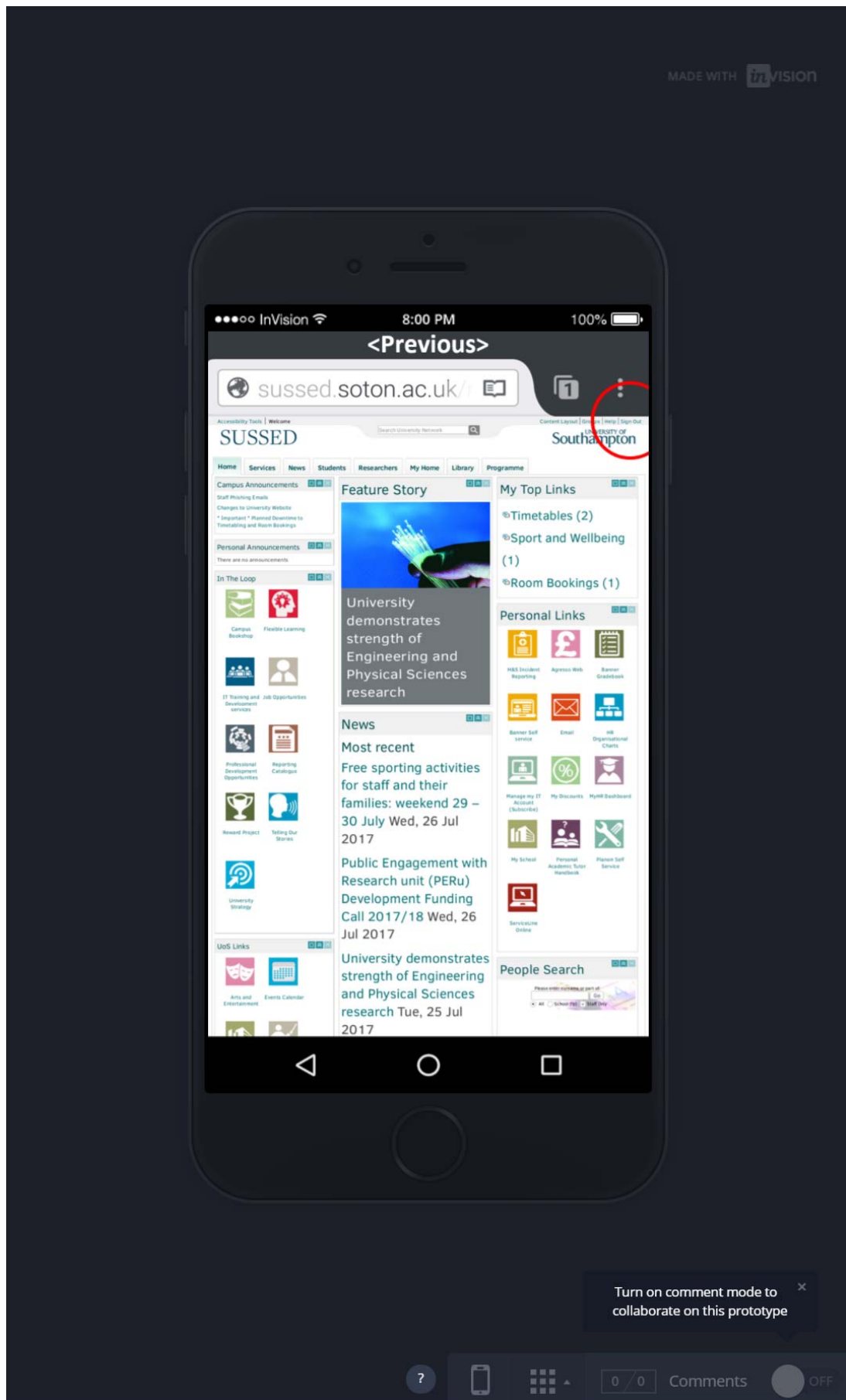


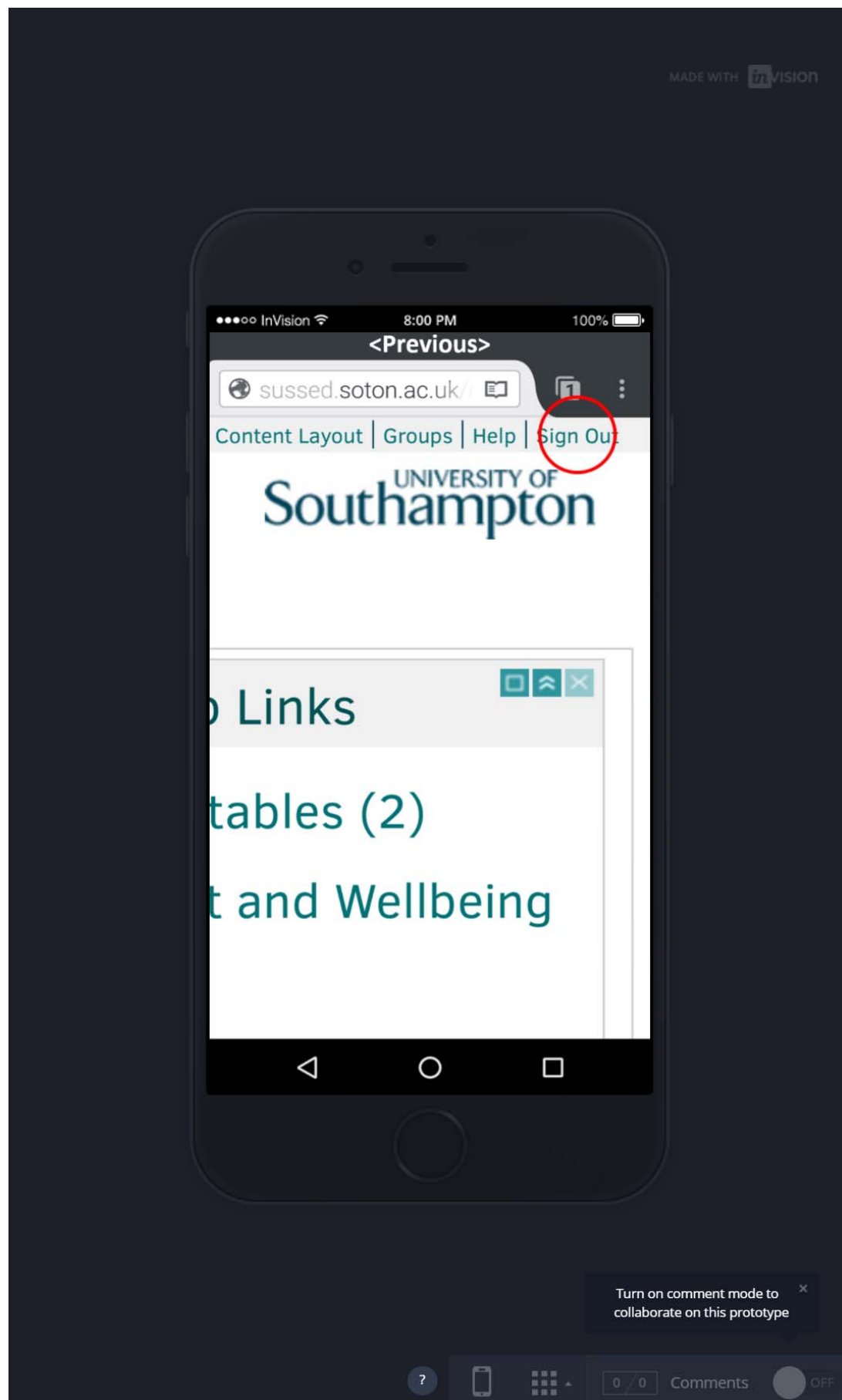


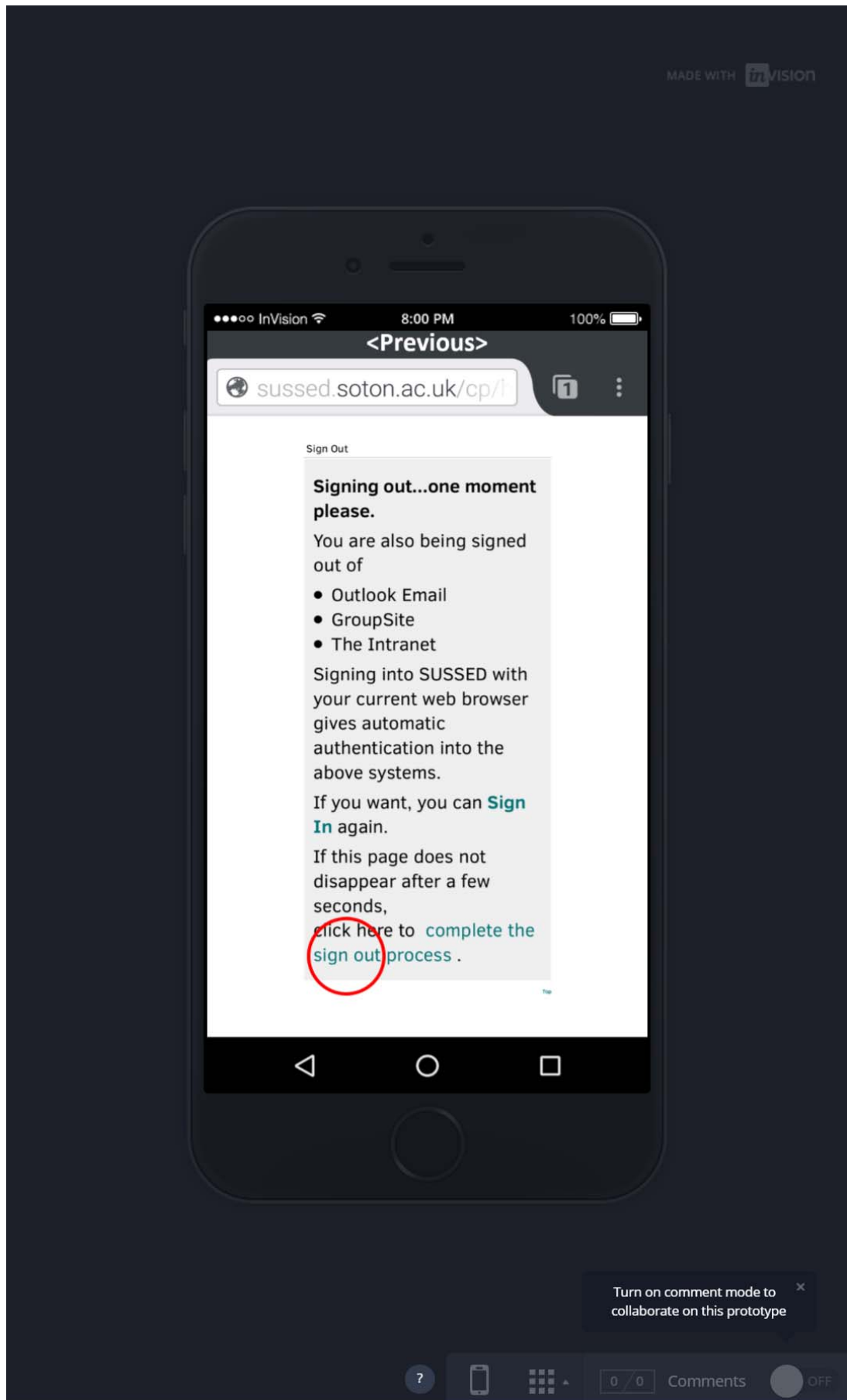


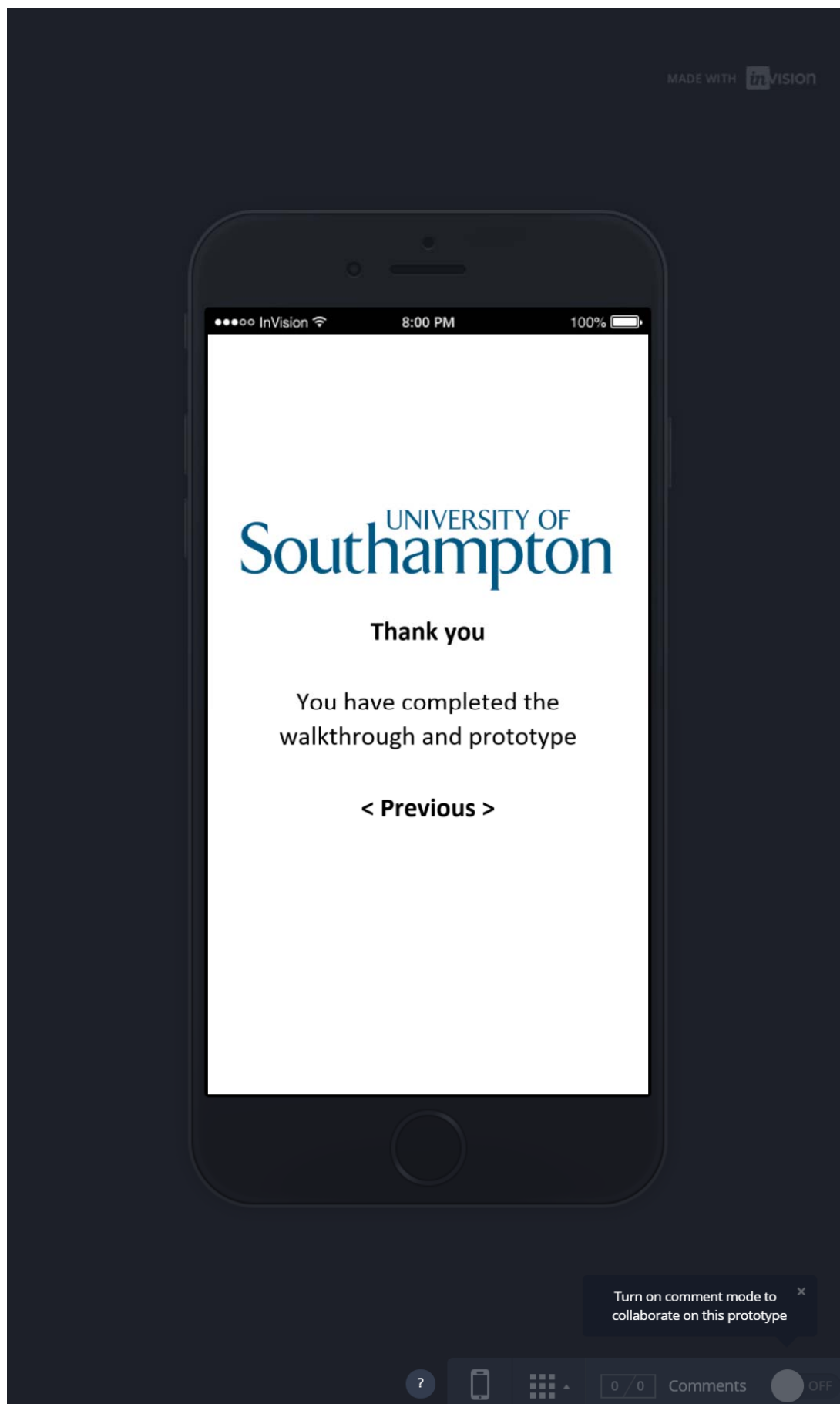












The following are screenshots, indicating exactly what the expert will see at the URL:

<https://expertreviewvalidation.wordpress.com/>.

The website will be deactivated on completion of the doctorate.



Expert Review Validation

RESULTS ADDITIONAL INFORMATION FOR PUBLISHERS AND LIBRARIANS

Results

The anonymised results of the survey will be made available on this page after the **23rd September 2017**.

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Expert Review Validation

RESULTS ADDITIONAL INFORMATION FOR PUBLISHERS AND LIBRARIANS

Additional Information for Publishers and Librarians

The following ereaders are currently available on Android, iOS and Windows smartphones, with the exception of Voice Dream and Lektz readers that are only available on Android and iOS. The reason Voice Dream reader was referred to in this expert review was that it has extensive accessibility features available. The epubtest.org website provides evaluations for epub3 reading systems.

Mobile eReader Application	Native	Online Reader	ePubtest.org
Adobe Acrobat Reader	Yes		
Adobe Digital Editions	Yes		Yes
Blio eBook Reader	Yes		Yes
Bluefire Reader	Yes †		Yes
Bureau van Dijk Reader (Publizard)	Yes ‡	Yes	Yes
Dyslektz (Requires Lektz ID)	Yes		
Gitden & PDF Plugin	Yes		Yes
Ideal Group Reader	Yes		
Lektz (Android & iOS)	Yes		Yes
Overdrive Media Console	Yes		Yes
Radium		Yes	
VI Reader	Yes		
Voice Dream Reader (Android & iOS)	Yes		Yes

Appendix H: Ethics applications for the expert reviews

† The Bluefire Reader is beginning to ingest publishers accessibility metadata, in that it allows the user to determine if a PDF can be printed, that text can be copied and pasted, and if it can be viewed on any device.

‡ The Publizard native app requires an Institute account, although you will need to contact Publizard to get a free trial (<http://publizard.com/contact/>). Sample ePub3 conformance test documents can be read online at <http://reader.bvdep.com/search/epubtest/Rank/>

Please note: the paid for Android version of VoiceDream has fewer features made available than the paid for the iOS counterpart. There is a lite version of VoiceDream for iOS. The Bluefire reader app for iOS allows text and background colour to be altered for ePub3's; whereas the Android version does not. The Android version of Adobe Acrobat Reader has been included simply because of its mainstream usage and that it provides reflow; whereas the Android Adobe Digital Editions offers the use of DRM protected formats. There is also a PDF/UA reference suite available at <https://goo.gl/AamJCw> that provides PDF's that comply with the PDF/UA standard ISO 14289-1:2014, but unfortunately does not go as far as the ePubtest.org by stating what readers have been tested.

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H.2.11 Consent information

Ethics reference number: ERGO/FPSE/30291	Version: 2	Date: 2017-09-07
Title of study: Expert Review Validation: Evaluating the mobile web accessibility of Higher Education electronic text for print impairments		
Investigator: Neil Rogers		


 Accessibility toolbar
 

Expert Review Validation

To increase type size in your browser please press 'CTRL' and '+' on a Windows PC or '⌘' and '+' on a MAC.

Please help us: to learn more about evaluating the mobile web accessibility of Higher Education electronic text for print impairments. This survey will be anonymous.

Prior to undertaking the survey, you will need to read the participant and consent information. This information is available as accessible Word documents and can be downloaded at the following URLs:

1. Participant Information (<https://goo.gl/ykgYQu>)
2. Consent Information (<https://goo.gl/xEshGz>)

 A password is required to access this survey. Please enter password below

☐ Please tick (check) this box to indicate that you have read and agree to both the participant and consent information.

Start this survey 

Appendix H: Ethics applications for the expert reviews

Ethics reference number: ERGO/FPSE/30291	Version: 2	Date: 2017-09-07
Title of study: Expert Review Validation: Evaluating the mobile web accessibility of Higher Education electronic text for print impairments		
Investigator: Neil Rogers		

The following consent information will be available as an accessible Word document at <https://goo.gl/xEshGz>

Ethics reference number: **ERGO/FPSE/30291**

CONSENT INFORMATION:

Participants are asked to indicate their agreement to the following statements.

I have read and understood the Participant Information (version 2 dated 2017-09-07).

I agree to take part in this study.

I understand my participation is voluntary and I may withdraw at any time and for any reason.

H.2.12 Data Protection Act (DPA) Plan

Ethics reference number: ERGO/FPSE/30291	Version: 2	Date: 2017-09-07
Title of study: Expert Review Validation: Evaluating the mobile web accessibility of Higher Education electronic text for print impairments		
Investigator: Neil Rogers		

The following is an exhaustive and complete list of all the data that will be collected (through survey questionnaires).

- Appendix II provides the list of all data that will be collected using iSurvey by questioning the expert participants. Pages 14-16 and pages 21-22 respectively of this document.
- The email addresses of the participants will not be collected during the survey.

Collecting the demographic data (*eg.* gender and age) is relevant to the study purposes because this will help provide a sample population. Collecting the expertise data is relevant to the study purposes because it will provide a means to compare subjective knowledge against actual expertise. Both sets of data are adequate for the same reasons.

Both sets of data are not excessive because they are only asking questions specific to determining a sample population and expertise.

The data will be processed fairly because the participants will have given implicit consent by placing a tick (check) in a box on iSurvey and then being given the option to 'Start the survey' prior to undertaking the review.

The data's accuracy is ensured because the official University of Southampton data gathering tool iSurvey is being used.

Data will be stored on a University server. The data will be held in accordance with University policy on data retention.

Data files will be protected by placing them in a folder on an official secured University server requiring a password and desktops will be protected by a password.

Appendix H: Ethics applications for the expert reviews

The data will be destroyed by the University at the conclusion of the doctorate through official channels.

Since the data collected is anonymous the participant will be unable to alter the data collected.

The data will be anonymised by removing any reference to age or gender when the results are published on (<https://expertreviewvalidation.wordpress.com/>). In addition to this, only a summary of the results at this URL will be provided. Where qualitative statements are given during the review these will be grouped into themes and summarised. It will also not be possible for the researcher to infer the identity of the participants based on gender, age or expertise because the data collected through iSurvey is anonymous.

Appendix I Specification for a web service and four separate web applications

This document is intended to be read by Dr Nasser Siabi (CEO) and the Board of Directors at Mircolink, and the developer(s) who will be involved in producing the web service and web applications. The aim of this document is to provide a specification for a web service and four web applications that can be used on any device or browser, developing further the initial Microlink Web Service proposed on the 13th May, 2013. One of these applications will be an ereader used by an academic or student in a Higher Education Institute (HEI). The HEI would provide a branded version of the app developed by Microlink or other collaborating stakeholders. It focuses on a three way relationship between the academic/student, the Higher Education Institute (HEI) Library and the Academic publisher, with particular emphasis from the outset on the publishing sector. In doing so, the specification begins to identify the interactions between the stakeholders, and then details a user story walkthrough skeleton. The walkthrough skeleton (wireframe), as the name suggests, provides the essential structure of what each stakeholder will be required to do when using the Web app. In particular this app is to be used by print impaired people. The specification will also need to be used in conjunction with the wireframe. It concludes with a summary. This specification is an overview of the entire web service and web applications, the first aspect required for development was the turn key component: accessibility metadata highlighted from the research. A proof of concept has been developed and demonstrates that accessibility metadata can be extracted from a PDF using a web service.

This specification is divided into five sections:

1. Introduction	pg. 508
2. Stakeholder Interactions	pg. 509
3. User Story – Walkthrough Skeleton	pg. 512
4. Summary	pg. 608

I.1 Introduction

In this section three aspects are considered. Firstly, the problem that the majority of academic publishers are not aware that there is an untapped market share. Secondly, the solution to this problem; and thirdly, in what way the publishing sector can benefit from the Microlink Web Service (MWS) and the separate web applications. This is then followed by a brief explanation as to the three way relationship between stakeholders, and more importantly how the publishing sector can impact the accessibility of electronic content at source with the use of the MWS. The MWS will support a single web app ereader developed in-house by Microlink that can recognise the accessible content provided by publishers. It is for this reason that the marketing of this web app needs to initially concentrate on the educational publishing sector.

I.1.1 The Problem

According to McNaught², when specialists in accessibility approach publishers and state that the publishing sector is missing out on 25% of their market share, the publishers respond by stating that they are not receiving 700 requests per day, and therefore the demand for the accessibility of digital content is not warranted. McNaught suggests that the reason for this is that academic and student users are unaware of 'what to ask for' and that HEI libraries have legacy workflows that are in the process of catching up with technology.

I.1.2 The Solution

Instead of trying to catch up with technology or the academic/student not knowing what to ask for, we use technology – namely the MWS, to enable each stakeholder to benefit.

I.1.3 Benefits

The publisher will benefit from the following, enabling monetisation of the MWS:

- Data relating to the demand of inaccessible electronic documents.

² [1] "Summary of two questions at the end of an ALT Format meeting," Personal Communication, N. Rogers, Ed., Southampton: University of Southampton, January 2016.

- In doing so this data will also help establish the priority of demand. So for example, if 1000 inaccessible flags are requested for a particular document over another single request for a document, the priority is clear.
- The means to quickly fix accessibility issues.
- The ability to promote their own titles similar to those downloaded by the user.
- Valuable research data for the marketing departments in publishing houses. Access to Publisher Lookup Ranking in one place.
- Accessible devices tested by experts through a feed from Web2Acces that can be resold by Microlink to be promoted through the publishers marketing channels.
- An ereader that the publisher can be confident the accessible format they provide will not be made inaccessible by the ereader.
- Customisation of electronic content for the academic or student user.

I.1.4 Stakeholder interactions

Figure I-1 indicates the three way relationship between stakeholders. Although there is a connection between all three stakeholders, the primary route for obtaining accessible electronic library content has been for the academic/student to liaise with the publisher indirectly through the HEI Library. SAGE, an educational publishing company, although already engaged in providing accessible electronic content to the academic or student community also liaises with librarians or disability officers in the HEI library. Academics or students, however, are able to gain direct access, through a single institute login process, to the copyrighted material that publishers make digitally available. Since this is copyrighted material, the academic or student is allowed to access the publication for free but is not permitted to disseminate the document into the public domain. If, however, the digital document does not have accessibility embedded at source direct from the publisher, the print impaired academic or student using a mobile device has to be referred to a librarian or disability officer in order to have an alternative format, such as braille or an audio file of the text, provided for them. This process is time consuming and costly for every stakeholder concerned. Furthermore, if an accessible document is created by the academic publisher, such as SAGE, this still does not guarantee that the academic or student will be able to access it. The login process through the institute library may not be accessible, and the device or eReader the academic or student is using might not be able to recognise and display accessible digital content. It is for this reason that the MWRA has

been designed to tightly control every aspect of this, providing a direct seamless channel to the academic or student requiring accessible digital HEI library content.

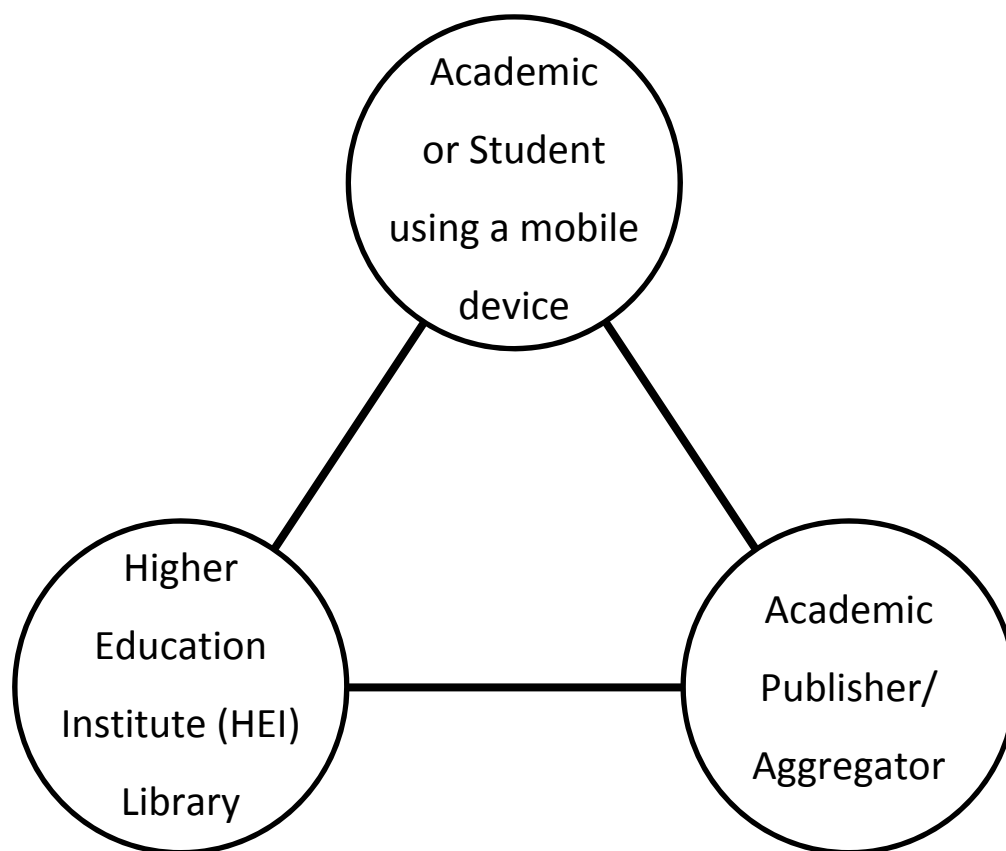


Figure I-1: The Three Way Relationship between stakeholders

The specification now turns here towards the initial stakeholder interactions and the user story walkthrough skeleton. Both sections are written for the developer(s) to begin producing the web app. It is also included here so the decision makers at Microlink are able to see what work is required by the developer(s). Figure I-2 provides a use case diagram with an overview of the entire Web Service.

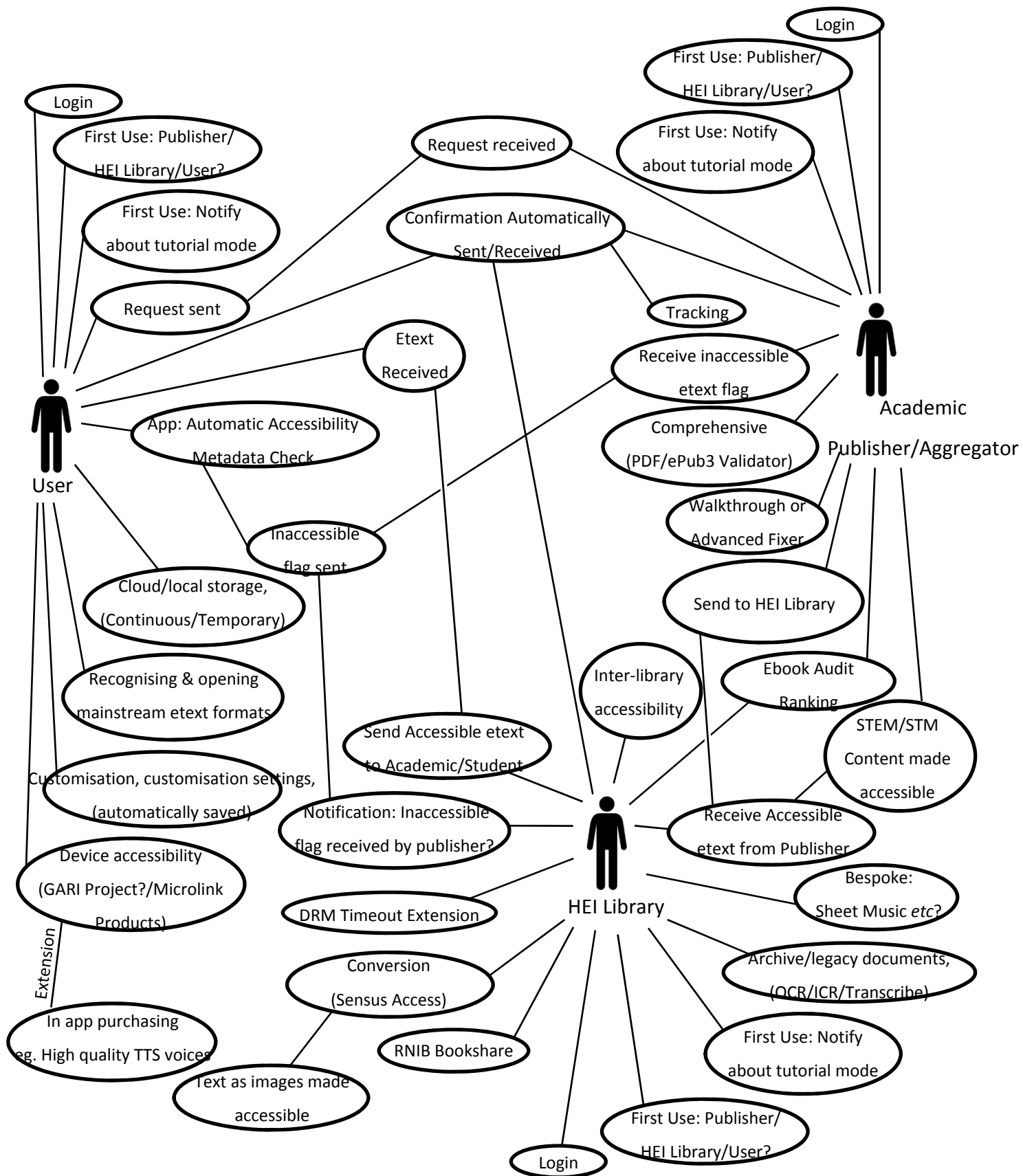


Figure I-2: Microlink Web Service use case diagram.

Appendix I: Specification for a web service and four separate web applications

The following appendix I.1.5 provides a breakdown of the user story in tabular form. For the first iteration of the respective stakeholder user interface designs please refer to the accompanying materials, presented as separate documents:

- 1 MWS Academic Student;
- 2 MWS Academic publisher;
- 3 MWS HEI Library.

I.1.5 User Story – Walkthrough Skeleton

The walkthrough skeleton, as the name suggests, provides the essential structure of what each stakeholder will be required to do when using the Web application. The user story is broken down into three columns:

Column 1: a specific user activity;

Column 2: the walkthrough skeleton itself; and

Column 3: what might happen between the user's device and the server running the MWS. This column may also contain a comment useful to the developer.

Throughout the User Story there are references to Release 1, 2, and 3. The majority of the developer requirements will fall within release one, except where otherwise stated. The hierarchy of the releases is as follows:

Release 1: Essential

Release 2: Desirable

Release 3: Future, this would include later releases.

This section provides a deliberately detailed user story for the developers benefit and enables decision makers at Microlink to see what is required in terms of work. One single version of the web application will accommodate stakeholder interactions for four different web app User Interfaces (UI), listed below. This list will also include the general settings for each UI prior to providing the walkthrough skeleton sequence:

3.1. Academic or Student using a mobile device:

3.1.1. Lite or Free (Guest) general settings	pg. 514
3.1.2. Lite or Free User Story	pg. 516
3.1.3. Institute general settings	pg. 538
3.1.4. Institute User Story	pg. 540
3.2. Academic Publisher/Aggregator general settings	pg. 570
3.3. Academic Publisher/Aggregator User Story	pg. 572

3.4. HEI Librarians general settings pg. 591

3.5. HEI Librarians User Story pg. 593

This section of the specification is then followed by the

3.6. Summary pg. 608

I.1.6 Lite or free (guest) general settings:

The following settings are an initial attempt at providing general settings for the lite or free aspect of the web app. The settings relating to permissions, notifications and online/offline functionality will be integrated into a summarised version of the settings.

- **Tutorial & Help Documentation**
 - Quick Start
 - Full Walkthrough
 - Smart Notifications
 - Help Documentation
 - Turn On/Off
- **Accessible etext Devices (Guest)**
 - Search for Device
 - Invite a friend
 - Share on Facebook or Twitter
- **Open Access etext Search (Guest)**
 - Invite a friend
 - Share on Facebook or Twitter
- **Institute Login (Registration)**
- **Download/Transfer**
 - Local
 - Cloud Storage
- **Document Management**
 - Folder Options
- **Reference Manager (Release2)**
 - Audio Annotations
 - Share Annotations (Collaborate)
- **Manage/Library of Voices**
 - Free
 - Purchase
- **Customisation**
 - *Navigation (touch)*
 - Menu Text Size
 - Finding/Searching
 - Speech Recognition
 - *Viewing the Screen*
 - Zoom
 - Reflow
 - Colour Changes:
 - Background Colour
 - Font Colour
 - Saturation

- Readability & Legibility
 - Style of Font
 - Font Size
 - Font Colour
 - Background Colour
 - Saturation
 - Text Alignment
 - Line Spacing
 - Margin Spacing
 - Overlay
 - Overlay Options
 - Full Screen Reading
 - Readability On/Off
 - *Audio*
 - Text to Speech
 - Rate of Speech
 - Pronunciation
 - Voice Library
 - Purchase Voices
 - User Behaviour Analytics
 - On/Off
 - Cloud Storage
 - Sign Out & Close

 - **Permissions**
 - User Behaviour Analytics
 - Cloud Storage
 - Google Drive
 - Dropbox
 - Temporary User Preferences

 - **Notifications**
 - On/Off
- Online/Offline Functionality**

3.1. Academic or Student using a mobile device

3.1.2. User Story: Lite or Free version of the web application: no login required & available to all.

User Activity:	Front End (Walkthrough Skeleton):	Backend/Server Side/Comment
Academic or Student		
The academic or student user will need to be able to open the institute branded web application on a smartphone or tablet device, it will open with the etext shelf showing a single sample etext ³ .	INSTITUTE BRANDED (By the HEI Library) FREE WEB APP:	The Microlink Web App (MWA) etext shelf will be based on the VoiceDream⁴ User Interface (UI) but with additional functionality. Please see the end of this document for an initial layout for the MWA etext Shelf UI. A burger menu will be available top left throughout the app regardless of whether the user is in the etext shelf or otherwise. On first login, a notification will appear over the etext shelf. For the lite or free version of the app, the user will not need to be asked what stakeholder they are. In this instance the academic and student have the same level of access to OA material.

³ The sample etext will need to contain Accessibility Metadata as suggested by Garrish, 2012 in Accessible ePub3, freely available as an ePub from <http://shop.oreilly.com/product/0636920025283.do>

⁴ <http://www.voicedream.com/wp-content/uploads/iOS-Simulator-Screen-Shot-Dec-2-2014-9.24.00-AM.png>

On first 'login', the user will need to be asked for permission for User Behaviour Analytics (UBA) to be collected. For now this feature will only be made available to participants who are given a participant login user name and password.	USER BEHAVIOUR ANALYTICS (UBA): Permissions Yes/No (Option 10 in General Settings)	If yes, continue. This will need to save a guest UBA log file to the local device that is automatically sent to the research labs when the user closes the app. It will need to provide a unique checksum guest ID. UBA will be required on every conceivable action a user might make. If no, then the app setting for UBA must be greyed out and not be functional. This is crucial for ethics approval.
On first 'login', the user will then need to be asked permission for the app to have access to cloud storage. Once selected the user will need to be asked about the use of ePub3.	CLOUD STORAGE: Google Drive Dropbox ...etc. Permissions Yes/No (Option 11 in General Settings)	If yes, continue. If no, the user will only be allowed access to documents stored locally on the device. This maybe for personal documents.

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User Activity:	Front End (Walkthrough Skeleton):	Backend/Server Side/Comment
Academic or Student		
On first login, after the user has selected yes or no to cloud storage, they will need to receive a notification about ePub3 usage.	NOTIFICATION: Have you used ePub3 before? Yes/No	If yes, continue to the next notification. If no, a demonstration of the accessibility features in ePub3 will need to be provided. This is to be deliberately in addition to the tutorial mode, for now, in order to help promote ePub3 and accessibility metadata for perhaps <i>Release 1</i> and 2 of the app.
On first login, the user will then need to receive an additional notification asking: 'Do you require a quick start tutorial?'	NOTIFICATION: Do you require a quick start tutorial? Yes/No?	If, yes the user will need to be provided with a quick start tutorial. If no, the user will need to be returned to the etext shelf.

If yes, the user will need to be able to follow simple steps to be shown around the etext Shelf and the eReader UI. The quick start option provides the user with only essential tutorials to get up and running quickly in a busy working environment.	QUICK START TUTORIAL (Basic – Release 1) <continue>	<i>Release one:</i> basic quick start tutorial where the user will be required to open the sample etext⁵ and carry out a search on an academic search engine in app, using a burger menu for general settings. <i>Release two:</i> would include a quick start tutorial about connecting to the institutes Virtual Private Network (VPN) on a smartphone or tablet.
The quick start tutorial will also need to introduce the Full Walkthrough Settings, Smart Notifications, Help Documentation and Turn On/Off Tutorial Mode to the user.	Quick Start: Full Walkthrough Smart Notifications Help Documentation Turn On/Off	Full Walkthrough, offers the user a complete tutorial for every aspect of the app through notifications. Smart Notifications, based on user behaviour, are notifications that only appear when the user appears to be struggling. Detailed accessible help documentation should be available on demand. The final option is to allow the user to turn the tutorial mode on/off.

⁵ This will be an ePub3 that contains the ONIX Accessibility Metadata referred to by Garrish, 2012, in Accessible ePub3, freely available as an ePub from: <http://shop.oreilly.com/product/0636920025283.do>

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User Activity:	Front End	Backend/Server Side/Comment
Academic or Student	(Walkthrough Skeleton):	
If no is selected on the quick start tutorial notification the user is returned to the etext Shelf. The user will need to be able to select the burger menu top left.	MOBILE INSTITUTE BRANDED WEB APP:	The burger menu contains the General Settings for the entire app. This will open as a scrollable side swipe menu with selectable general settings.

The user will need to select the top left burger menu, opening a scrollable side swipe General Settings menu and will then need to be able to navigate to and select one of the following twelve options: 1.Tutorial & Help Documentation 2.Accessible etext Devices (Guest) 3.Open Access etext Search (Guest) 4.Institute Login (Registration) 5.Download/ Transfer 6.Document Management 7.Reference Manager (Release2) 8.Manage/Library of Voices 9.Customisation 10.User Behaviour Analytics 11.Cloud Storage 12.Sign Out & Close	GENERAL SETTINGS (Guest) 1.Tutorial & Help Documentation 2.Accessible etext Devices (Guest) 3.Open Access etext Search (Guest) 4.Institute Login (Registration) 5.Download/ Transfer 6.Document Management 7.Reference Manager (Release2) 8.Manage/Library of Voices 9.Customisation 10.User Behaviour Analytics 11.Cloud Storage 12.Sign Out & Close	Third party purchases for accessible etext devices can take place outside the institute login and are part of the free app or lite version. Microlink are able to market to third parties. The GARI Project⁶ has no dates , other than device versions, or criteria available on the website. Web2Access, provides expert tested devices that Microlink can resell. All settings available in app for the institute search must be greyed out for the lite version of the app. If the UBA is activated then the user must be able to alter the order of the General Settings. The order of the settings can be saved to a temporary preference file stored locally on the device.

⁶ <https://www.gari.info/>

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<i>Release 2:</i> In the same way a web page navigation works, if the user selects an option on a summarised General Settings menu, the menu jumps directly to the chosen option that indicates nested sub-menu items.	Release 2: Jump to Settings	So for example, 'Customisation' settings will be towards the end of the general settings. <i>Release 2:</i> The UBA will need to record if the user uses the 'skip to navigation' or scrolls down the side swipe menu. This will be the same for all settings in the side swipe menus.
User Activity: Academic or Student	Front End (Walkthrough Skeleton):	Backend/Server Side/Comment
If Tutorial & Help is selected in General Settings (Guest), the user will need to be provided with five side menu options, namely: Quick Start Full Walkthrough Smart Notifications Help Documentation Turn On/Off	1. Tutorial & Help: Quick Start Full Walkthrough Smart Notifications Help Documentation Turn On/Off	The quick start option provides the user with only essential tutorials to get up and running quickly in a busy working environment. Full Walkthrough, however, offers the user a complete tutorial for every aspect of the app through notifications. Smart Notifications, based on detecting user tactics, are notifications that only appear when the user appears to be struggling. Detailed accessible help documentation should be available on demand. The final option is to allow the user to turn the tutorial mode on/off.

If Accessible etext Devices is selected in General Settings (Guest), the user will need to be able to select from one of the following three options: 1.Search for a device 2.Invite a friend. 3.Share the Microlink Accessible Devices on Facebook, Twitter or other suitable social media.	2. Accessible etext Devices: 1.Search for Device 2.Invite a friend 3.Share on Facebook or Twitter	The search for an expert tested Microlink device, will need to be based on the users accessibility requirements and driven by Web2Access. The University of Southampton accessibility research could take a percentage.

User Activity:	Front End	Backend/Server Side/Comment
Academic or Student	(Walkthrough Skeleton):	
If Open Access etext Search is selected in General Settings (Guest) the user will need to be able to perform a combined search of all search engines that will contain OA material. Note: Google Scholar returns all results, it does not currently allow a filter for <i>just</i> Open Access or Open Educational Resources (OER) results.	3. Open Access etext Search Invite a friend Share on Facebook or Twitter <i>(Stakeholder Interaction)</i>	The open access search will only return results – from a meta search of Google Scholar, Project Gutenberg <i>etc</i> – that are Open Access, Creative Commons or Copyright Free. <i>Release 2:</i> An additional feature would be to include only the freely available Abstracts and referencing of journal papers and the like. It would also need to be possible for the user to order the results, in ascending or descending order. So for example, freely available Abstracts from Journals first then OA material following or <i>vice versa</i>. This could also scrape ePrints for example. This functionality would be available in the free version of the app. This could also be configured for college, school and pre-school searches.

On first login, if Open Access etext Search is selected in General Settings (Guest), the user will need to receive a notification explaining the difference between an Open Access search and an Institute search. This notification would use the device notification tray and drop down menu. The user will then need to be asked about permissions for cloud storage.	NOTIFICATION: Difference between Open Access & Institute Search <continue>	Google Scholar undertakes meta searches across many, but not all, academic search engines (the HEI library must state exactly which these are so they can be made available in app). Project Gutenberg is problematic because the majority of books available copyright free in the US are outside of copyright in the UK. An institute search requires authentication to subscribed library services.

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User Activity:	Front End	Backend/Server Side/Comment
Academic or Student	(Walkthrough Skeleton):	
The user will then need to have the results of the combined search presented to them as a results page and indication of format offered stating if the PDF is tagged for accessibility or the ePub has accessibility metadata available.	Combined OA Search (Guest) Results Returned	With a Get Document call from the server, the accessibility metadata and accessibility of the document needs to be checked using PAVE if a PDF, or ePubCheck for an ePub. Since this is the academic/student side it will only need to be a basic quick automatic check. The returned results need to provide basic accessibility information about the potential format to be downloaded. A what's does this mean link next to, for example this PDF has been tagged for accessibility, would help promote and educate the general public about accessibility.

If Download or Transfer is selected in General Settings (Guest), the user would need to be able to download the PDF directly or transfer it to the cloud. The Publisher, RNIB Bookshare, Sensus Access or bespoke service would provide a link. The file can be downloaded or transferred to Dropbox or Google Drive <i>etc.</i>	5. Download Local Transfer Cloud storage	Dropbox or Google Drive will need to be used for cloud storage. If 'local' is chosen then enable the user to download to their device. If transfer to the cloud is chosen then files need to be moved to Dropbox or Google Drive respectively. This would be achieved accessing a scrollable side swipe burger menu bar and importing the file.
If Document Management is selected in General Settings (Guest), the user will be able to create new folders or delete locally or in the cloud through a side swipe scrollable menu – if using a small screen device. This must be accessible allowing the user to navigate through the files easily and quickly.	6. Document Management Create folders on device or in the	If the user changes the file tree offline for cloud storage, the app will need to update the file tree when the app syncs online.

User Activity:	Front End (Walkthrough Skeleton):	Backend/Server Side/Comment
Academic or Student <i>Release 2:</i> If Reference Manager is selected in General Settings (Guest), the user will need to be able to access a reference manager that not only controls references, but also annotations, bookmarks and highlights. In particular the app must also be able to allow the user to create audio annotations. The user will also need to be able to share annotations for collaboration.	Release 2: 7. Reference Manager <i>eg. Audio Annotations</i> Share annotations <i>(Stakeholder Interaction)</i>	This will be required in release two of the Web app. Having a reference manager will also appeal to the majority of students rather than just the 4% of print impaired students in Higher Education (HE) in the UK. The app will need to be able to export to mainstream bibliographic managers such as Endnote, Mendeley, Zotero <i>etc.</i> Conversely it will need to be able to import from them as well.
If Manage/Library of Voices is selected in General Settings (Guest), the user will need to be able to access free voices such as Graham (Acapela). The user will also need to be able to purchase Microlink voices such as Nawars Arabic corpus.	8. Manage/Library of Voices: Free & Purchase	<i>Release 2:</i> Third party voices could also be purchased with a percentage taken by Microlink.

On exiting the General Settings burger menu, the user will need to be able to download OA etexts from the cloud to the shelf from the cloud in the free institute branded app and select them as required.	OPEN ACCESS APP: (Guest) etext shelf <select title>	The institute will be able to promote their own OA, OER, MOOC and other resources through in app self advertising. So for the University of Southampton this might also include ePrints. This is where the institute will be getting free advertising and so will get ROI for the purchase of the institute app and licence. <i>Release 3:</i> It may even be possible to tie advertising to content the user is reading at a later stage.
Once the user selects an OA title from the shelf, it will open in the Microlink Web App eReader. The user will then need to be able to navigate within the eContent and move focus through all selectable options.	ONLINE The Microlink Web App (MWA) OA eReader User Interface (UI) (Guest)	The guest access OA eReader UI will need to have all the core functionality of the institute search eReader. Please see the end of this document for an initial layout of the eReader UI. <i>Release 2:</i> Will include a feature that helps the user when reading in direct sunlight or bright conditions.

User Activity: Academic or Student	Front End (Walkthrough Skeleton):	Backend/Server Side/Comment
The user will need to receive a notification to use Text to Speech if the maximum font size on a small screen device is reached.	NOTIFICATION: You may wish to use Text To Speech (TTS)	So for example, if the maximum font size of 18pt (24px) is reached on a small screen device and the user keeps using gestures on screen to increase font size, then a notification stating that ‘you may wish to use TTS’ appears.
The user will also need to be able to read the book they are currently in, with a temporary download or be able to access and read books stored on their device when in offline mode. For example when the device is in Airplane Mode.	OFFLINE The Microlink Web App (MWA) eReader User Interface (UI) (Guest)	The app will need to automatically reflow any imported mainstream format, such as PDF, ePub, Mobi, DocX, RTF and TXT. The Amazon AZW format requires manual parsing and is a low priority and marked for <i>Release 3</i> or later. An option to turn reflow on/off will also need to be available. The text on screen will need to be responsive and allow a maximum font size of 18pt (24px) (Luz Rello, 2014) for small screen devices whether online or offline. The offline version will also require a reading in sunlight option. <i>Release 3</i> : Will require a setting to alter colour temperature based on the time

		of day and geo-location.
The user will need to receive a notification stating what book is currently being read.	NOTIFICATION: Current book being read.	The notification should appear in the system tray at the top of the screen on a mobile device whether in online or offline mode. This is to allow the user to remember what book is being read while using other apps.
On first login, the user will need to be asked permission to temporarily store user preferences to the device – similar to web cookies. This is to help the user when selecting and adjusting settings under customisation.	Save Temporary User Preferences to device? Permissions Yes/No	If yes, continue. If no, the user will need to receive a further notification stating that their customisation settings will not be saved.

User Activity: Academic or Student	Front End (Walkthrough Skeleton):	Backend/Server Side/Comment
If Customisation is selected from the General Settings (Guest), the user will need to be able to alter settings in the new functional categories.	9. Customisation: Navigation Viewing Screen Readability & Legibility Audio	In the free or lite version of the app the user will not be able to move functional categories up and down. All other core functionality will need to be available to the user. The new functional categories were obtained from the expert review in January 2016. The new categories to select from will be Navigation, Viewing Screen, Readability & Legibility and Audio. These side swipe scrollable menus will be available at any stage in app.

If Navigation is selected within Customisation (Guest), the user will then be able to alter the following settings: - Menu Text Size - Finding/Searching - Touch Controls The user must also, through a long press, be able to move the sub settings up and down within a category, again this will need to be recorded by the UBA. The app GTasks (Google Tasks for Android demonstrates this⁷).	Navigation Settings: - Menu Text Size - Finding/Searching - Touch Controls - Speech Recognition	The menu text size adjustment will aid navigation within and between each component of the framework, namely: Discovery, Metadata, eContent Format, eReader and eContent. Finding/Searching – user determined categories, or auto alphabetical menu lists to aid navigation. Touch Controls – customisation of touch functionality for navigation. Speech recognition will also be required so the user can control the UI experience hands free. So for example, next paragraph, stop, annotate. If a user is driving this may cause split attention.

⁷ https://play.google.com/store/apps/details?id=org.dayup.gtask&hl=en_GB

If Viewing the Screen is selected within Customisation (Guest), the user will then be able to alter the following settings: Zoom Reflow Colour Changes Background Colour Font Colour Saturation	Viewing the Screen Settings: Zoom Reflow Colour Changes: Background Colour Font Colour Saturation	The user must also, through a long press, be able to move the sub settings and groups of nested settings up and down within a category, again this will need to be recorded by the UBA.

User Activity:	Front End (Walkthrough Skeleton):	Backend/Server Side/Comment
Academic or Student		
If Readability & Legibility are selected within Customisation (Guest), the user will then be able to alter the following settings: - Style of Font - Font Size - Line Spacing - Margin Spacing - Overlay - Overlay Options - Font Colour - Full Screen Reading	Readability & Legibility: Style of Font Font Size Font Colour Text Alignment Line Spacing Margin Spacing Overlay Overlay Options	The user must also, through a long press, be able to move the sub settings and groups of nested settings up and down within a category, again this will need to be recorded by the UBA. Note: Font Colour is a duplicate setting, referred to as redundancy (Wechsung, 2014), whereby a user does not need to open two menu settings.
If Full Screen Reading is selected from Readability & Legibility, the user will then be able to turn on and off readability. When in full screen mode, readability is by default set to ON. The Readability setting is taken from the app⁸ and used by ATbar⁹.	Full Screen Reading (Readability On/Off)	Ensure this information is collected by the UBA, it will help determine if full screen reading is used over non-full screen reading. Also set media queries/features for reading such that landscape is for reading sentences, portrait for reading paragraphs.

⁸ <https://play.google.com/store/apps/details?id=com.readability&hl=en>

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If Audio is selected from General Settings (Guest), the user will then be able to alter the following settings: - Text to Speech - Rate of Speech - Pronunciation - Voice Library The user, through a long press, will be able to move the sub settings up and down within a category, again this will need to be recorded by the UBA.	Audio Settings: - Text to Speech - Rate of Speech - Pronunciation - Voice Library - Purchase Voices	It is important that the user still has access to the core functionality of the institute search audio settings, in particular pronunciation and voice library. The free version of the app must also provide in app purchases such as voices from Mircolink in app.

⁹ <https://www.atbar.org/>

User Activity: Academic or Student	Front End (Walkthrough Skeleton):	Backend/Server Side/Comment
If Sign Out & Close are selected in General Settings (Guest), the user will need to be able to close the free or lite app at any stage and return where they left off.	12. Sign Out & Close Free App	Since the free app does not require login a user preference file will need to be temporarily stored on the users device. If the user is downloading an etext, and there is temporary disconnection the app must automatically resume download on reconnection.

I.1.7 Institute general settings:

The following settings are an initial attempt at providing general settings for the institute aspect of the web app. The settings relating to authentication, permissions, notifications and online/offline functionality will be integrated into a summarised version of the settings.

- **Tutorial & Help Documentation**
 - Quick Start
 - Full Walkthrough
 - Smart Notifications
 - Help Documentation
 - Turn On/Off
- **Branding App**
 - Templates
 - Import Corporate Stationery
- **Accessible etext Devices (Institute)**
 - Search for Device
 - Invite an institute friend
 - Share on Facebook or Twitter
- **Open Access etext Search (Institute)**
 - Update Academic Search Engine list from HEI Library (Set to Auto)
- **Institute etext Search**
 - Update Academic Search Engine list from HEI Library (Set to Auto)
- **Stakeholder Interaction**
 - Inaccessible Flag
 - Simple
 - Complex
 - Send Options
 - Passed Check (Inaccessible)
 - Audit Report
 - Invite institute friend
 - Barrier Recording (Release 2)
- **Download/Transfer**
 - Local
 - Transfer
- **Document Management**
 - Folder Options
- **Reference Manager (Release 2) *eg.***
 - Audio Annotations
 - Share Annotations (Collaborate)
- **Manage/Library of Voices**
 - Free

- Purchase
- **Customisation**
 - Navigation (touch)
 - Menu Text Size
 - Finding/Searching
 - Speech Recognition
 - Viewing the Screen
 - Zoom
 - Reflow
 - Colour Changes:
 - Background Colour
 - Font Colour
 - Saturation
 - Readability & Legibility
 - Style of Font
 - Font Size
 - Font Colour
 - Text Alignment
 - Line Spacing
 - Margin Spacing
 - Overlay
 - Overlay Options
 - Full Screen Reading
 - On/Off
 - Readability On/Off
 - Audio
 - Text to Speech
 - Rate of Speech
 - Pronunciation
 - Voice Library
 - Purchase Voices
- **User Behaviour Analytics**
 - On/Off
- Cloud Storage

- **Authentication**
- Registration
- Login
- Change User

- **Permissions**

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- User Behaviour Analytics
- Cloud Storage
 - Datanywhere
 - Google Drive
 - Dropbox
- Temporary User Preferences
- **Notifications**
 - On/Off

Online/Offline Functionality

<i>3.1.4. User Story: Institute version of the web application: registration and/or login is required.</i>		
User Activity:	Front End (Walkthrough Skeleton):	Backend/Server Side/Comment
Academic or Student		
The academic or student user will need to be able to open the institute branded web application on a smartphone or tablet device, it will open with the etext shelf showing a single sample etext ¹⁰ .	MOBILE INSTITUTE BRANDED WEB APP:	Progress through each etext must be available to the academic or student in the etext shelf. The general settings burger menu will need to be available top left whether in the etext shelf or eReader UI.

¹⁰ The sample etext will contain Accessibility Metadata as suggested by Garrish, 2012 in Accessible ePub3.

If option 4 in Guest General Settings> Institute Login (Registration) (Page 5) is selected, the user will need to be able to login or register with an institute account. On first login the user will need to receive a notification about registration and then be able to register through the HEI libraries authentication process on. Once registered and logged on the user will need to be asked for User Behaviour Analytics permissions. Both the academic and student will need to be able to use the eReader. After first login, the user will need to be able to use the top left burger menu. The HEI Library oversees the academic or student	INSTITUTE LOGIN Authentication: Registration Login Change User	Registration would need to be taken from a federated single sign on – Identity Provision (IdP), for all authenticated academic search engines subscribed to by the HEI Library. This would be in the form of either Shibboleth¹¹, currently used by the University of Southampton or Athens¹². Both are Open Source and freely available. This would only need to be undertaken once, unless Change User is selected. If the user is an Academic their login will give them academic permissions. Academics will have privileges students do not. For example, ordering accessible texts the library is not currently subscribed to. The notifications will need to appear in the device notification tray and drop down menu. Items in the drop down menu will need to be selectable. This notification will then need to be followed by asking the

¹¹ <https://shibboleth.net/>

¹² <https://docs.openathens.net/display/public/LA/OpenAthens+LA+overview>

institute eReader app.		user for User Behaviour Analytics permissions.

User Activity:	Front End (Walkthrough Skeleton):	Backend/Server Side/Comment
Academic or Student		
The user will need to be asked for permission for User Behaviour Analytics (UBA) to be collected. For now this feature will only be made available to participants who are given a participant login user name and password.	USER BEHAVIOUR ANALYTICS (UBA): Permissions Yes/No	If yes, continue. This will need to save a guest UBA log file to the local device that is automatically sent to the research labs when the user closes the app. It will need to provide a unique check sum guest ID. If no, then the app setting for UBA must be greyed out and not be functional. This is crucial for ethics approval when undertaking on device data gathering.
On first login, the user will then need to be asked permission for the app to have access to cloud storage. Once done the user will then need to be asked about ePub3 usage.	CLOUD STORAGE: (Institute) Datanywhere Google Drive Dropbox ...etc. Permissions Yes/No	If yes, continue. If no, the user will only be allowed access to documents stored locally on the device. This maybe for personal documents. Note: Datanywhere¹³ uses the institutes own servers to provide secure cloud storage. For now the prototype web app

¹³ <https://www.varonis.com/products/datanywhere/>

		will need to have access to Google Drive and Dropbox.
On first login, after the user has selected yes or no to cloud storage, they will need to receive a notification about ePub3 usage. Have you used ePub3 before? Yes/No	NOTIFICATION: Have you used ePub3 before? Yes/No	If yes, continue to the next notification. If no, a demonstration of the accessibility features in ePub3 will need to be provided. This is to be deliberately in addition to the tutorial mode, for now, in order to help promote ePub3 and accessibility metadata for perhaps <i>Release 1</i> and 2 of the app.
On first login, the user will then need to receive an additional notification asking: 'Do you require a quick start tutorial?'	NOTIFICATION: Do you require a quick start tutorial? Yes/No?	If, yes the user will need to be provided with a quick start tutorial. If no, the user will need to be returned to the etext shelf.

User Activity: Academic or Student	Front End (Walkthrough Skeleton):	Backend/Server Side/Comment
If yes, the user will need to be able to follow simple steps to be shown around the etext Shelf and the eReader UI. The quick start option provides the user with only essential tutorials to get up and running quickly in a busy working environment.	QUICK START TUTORIAL (Basic – Release 1) <continue>	<i>Release one:</i> basic quick start tutorial where the user will be required to open the sample etext¹⁴ and carry out a search on an academic search engine in app, using a burger menu for general settings. <i>Release two:</i> would include a quick start tutorial about connecting to the institutes Virtual Private Network (VPN) on a smartphone or tablet.
The quick start tutorial will also need to introduce the Full Walkthrough Settings, Smart Notifications, Help Documentation and Turn On/Off Tutorial Mode to the user.	Quick Start: Full Walkthrough Smart Notifications Help Documentation Turn On/Off	Full Walkthrough, offers the user a complete tutorial for every aspect of the app through notifications. Smart Notifications, based on detecting user tactics , are notifications that only appear when the user appears to be struggling. Detailed accessible help documentation should be available on demand. The final option is to allow the user to turn the tutorial mode on/off.

¹⁴ This will be an ePub3 that contains the ONIX Accessibility Metadata referred to by Garrish, 2012, in Accessible ePub3, freely available as an ePub from: <http://shop.oreilly.com/product/0636920025283.do>

If no is selected on the quick start tutorial notification (see page 15) the user is returned to the etext Shelf. The user will need to be able to select the burger menu top left.	MOBILE INSTITUTE BRANDED WEB APP: etext shelf (One Sample etext)	The burger menu contains the general settings for the entire app. This will open as a scrollable side swipe menu with selectable general settings.

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User Activity:	Front End (Walkthrough Skeleton):	Backend/Server Side/Comment
Academic or Student		
Within the etext shelf the user will need to select the top left burger menu of the etext Shelf, opening a scrollable side swipe General Settings menu. The user will then need to be able to navigate to and select one of the following 13 options: 1. Tutorial & Help Documentation 2. Accessible etext Devices (Institute) 3. Open Access etext Search (Institute) 4. Institute etext Search 5. Stakeholder Interaction 6. Download/Transfer 7. Document Management 8. Reference Manager (Release 2) 9. Manage/Library of Voices 10. Customisation 11. User Behaviour Analytics 12. Cloud Storage 13. Sign Out & Close	INSTITUTE GENERAL SETTINGS 1. Tutorial & Help Documentation 2. Accessible etext Devices (Institute) 3. Open Access etext Search (Institute) 4. Institute etext Search 5. Stakeholder Interaction 6. Download/Transfer 7. Document Management 8. Reference Manager (Release 2) 9. Manage/Library of Voices 10. Customisation 11. User Behaviour Analytics 12. Cloud Storage 13. Sign Out & Close	If Accessible etext Devices is selected this enables the user to Purchase expert vetted or tested devices from Microlink (driven by Web2Access). If Open Access is chosen then a list of public domain search engines need to be offered in app. If an Institute search is chosen then again a list of only authenticated academic search engines should be made available in app. Note: VoiceDream enables searching in app on Google.

<i>Release 2:</i> In the same way a web page navigation works, if the user selects an option on the summarised general settings menu, the menu jumps directly to the chosen option and its nested items.	Release 2 Jump to Settings	So for example, 'Customisation' settings will be towards the end of the general settings. <i>Release 2:</i> The UBA will need to record if the user uses the 'skip to navigation' or scrolls down the side swipe menu. This will be the same for all settings in the side swipe menus.

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User Activity: Academic or Student	Front End (Walkthrough Skeleton):	Backend/Server Side/Comment
If Tutorial & Help Documentation is selected in General Settings (Institute), the user will need to be provided with five side menu options, namely: Quick Start Full Walkthrough Smart Notifications Help Documentation Turn On/Off	1. Tutorial & Help Documentation: Quick Start Full Walkthrough Smart Notifications Help Documentation Turn On/Off	The quick start option provides the user with only essential tutorials to get up and running quickly in a busy working environment. Full Walkthrough, however, offers the user a complete tutorial for every aspect of the app through notifications. Smart Notifications, based on detecting user tactics, are notifications that only appear when the user appears to be struggling. Detailed accessible help documentation should be available on demand. The final option is to allow the user to turn the tutorial mode on/off.

If accessible etext devices is selected in General Settings (institute), the user will need to be able to select one of the following three options: 1. Search for a device 2. Invite an institute friend. 3. Share the Microlink Accessible Devices on Facebook, Twitter or other suitable social media.	2. Accessible etext Devices: 1. Search for Device 2. Invite an institute friend 3. Share on Facebook or Twitter	The search for and purchase of an expert tested Microlink device, based on the users accessibility requirements, will need to be driven by Web2Access¹⁵. The University of Southampton accessibility research could take a percentage.
If Open Access etext Search is selected in General Settings (Institute), the user will need to be able to isolate a single OA search engine if required. Conversely, the user will need to be able to select all OA search engines if required. VoiceDream enables searching in app on Google.	3. Open Access etext Search (Institute): Select All Google Scholar ☒ Project Gutenberg ☒ ...etc.	The difference between OA Search for a guest and OA Search for institute is that the guest option only allows a combined search; whereas the institute version allows the user to isolate a specific OA search, such as Project Gutenberg. If the library have OA databases that are not scraped by Google Scholar, these will need to be highlighted.

¹⁵ <http://web2access.org.uk/>

User Activity: Academic or Student	Front End (Walkthrough Skeleton):	Backend/Server Side/Comment
On first login, the user will need to receive a notification explaining the difference between an Open Access and Institute search.	NOTIFICATION: Difference between Open Access & Institute Search <continue>	Google Scholar undertakes meta searches across many, but not all, academic search engines (the HEI library must state exactly which these are so they can be made available in app). Project Gutenberg is problematic because the majority of books are available copyright free in the US but are outside of copyright in the UK. The institute search provides access to search engines Google Scholar is not able to scrape.
On the Open Access etext search if Google Scholar is isolated by the user then the results need to be returned as a web list and an indication of format offered. The institute app will only need to check for: PDF: Tagged for accessibility, Headings, Tabbing Order Reading Order Set, Alt Text for images. ePub:	eg. Google Scholar Search Results returned eg. PDF Tagged or not tagged for accessibility	With a Get Document call from the server, the accessibility metadata and accessibility of the document needs to be checked using PAVE if a PDF, or ePubCheck for an ePub. Since this is the academic/student side it will only need to be a basic quick automatic check. This fields any Small to Medium Enterprise (SME) Publishers, perhaps unaware of accessibility or who do not have the resources available to meet accessibility requirements.

ONIX Accessibility Metadata		
If Institute etext Search is selected in General Settings (Institute), the user will then need to be able to select the academic search engines they wish to search. If the institute library does not have access to a particular academic search engine it should be greyed out in app and not allow the user to check it. It should also be possible for the user to re-order the list in ascending or descending order; or by selected items only; or by semantic search engines.	4. Institute etext Search: Select All ACM ☒ IEEE ☒ Web of Science ☒ Not available ☐ ...etc.	The Papers app allows combined searches of academic search engines in app - http://papersapp.com/mac/ This provides an example to help with the back end development. Another aspect will be semantic or smart searches such as, https://www.semanticscholar.org/, appealing to the majority of students rather than just the 4% of print impaired students in Higher Education in the UK.

User Activity: Academic or Student	Front End (Walkthrough Skeleton):	Backend/Server Side/Comment
The user will need to have the results of the combined or isolated institute search presented to them as a standard results page with an indication of format offered stating if the PDF is tagged for accessibility or the ePub has accessibility metadata available.	Combined or Isolated Institute Search Results Returned	With a Get Document call from the server, the accessibility metadata and accessibility of the document needs to be checked using PAVE if a PDF, or ePubCheck for an ePub. Since this is the academic/student side it will only need to be a basic quick automatic check.
If Stakeholder Interaction is selected in General Settings (Institute), the user will need to be able to select one of the following four options: 1. Inaccessible Flag 2. Audit Report 3. Invite institute friend 4. Barrier Recording (Release 2)	5. Stakeholder Interaction 1. Inaccessible Flag 2. Audit Report 3. Invite institute friend 4. Barrier Recording (Release 2)	The inaccessible flag option will allow the user to send a simple or complex document back to the publisher to be made accessible. The audit report will allow the user to see a status for any outstanding inaccessible flags made. The Invite an Institute Friend will also include being able to invite Academics. The Barrier Recording option will be made available in a <i>Release 2</i>.

If Inaccessible Flag is selected in Stakeholder, the user will need to be able to select the required academic etext from the results page. It maybe that the required academic etext is inaccessible and needs to be processed. If it is a simple document the file needs to be sent directly to Sensus Access. If, however, it is a complex document it needs to be sent to the Publisher, RNIB Bookshare or bespoke services such as Music Sheet services.	<i>eg. PDF</i> 1. Inaccessible Flag Simple? - Not Tagged - No Headings Complex? - MathML - Sheet Music <SEND>	The publisher and HEI library need to be notified automatically. Only at this point should a server side database be generated for each inaccessible document processed. Important: this will help determine demand for the publisher and other stakeholders. Simple documents could be automatically determined by the app, but intervention by the academic or student maybe required for complex documents, particularly in terms of meeting their accessibility requirements.

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User Activity:	Front End (Walkthrough Skeleton):	Backend/Server Side/Comment
Academic or Student		
If Audit Reports is selected in Stakeholder Interaction, the user will need to be able to be presented with what stage any accessible flag is at.	2. Audit (Report)	The audit report must allow the user to view any stage of the process between the library and the publisher and themselves.
If Invite an Institute Friend or Academic is selected in Stakeholder Interaction, the user to be able to invite other students or academics from the same institute but on other campuses. So for example, the University of Southampton inviting a user from University of Southampton Malaysia. This would need to be in addition to the institute stating the app is available at the beginning of term or the semester.	3. Invite an institute Friend or Academic	In VoiceDream the user is also offered the option of writing a review for the app or contacting the app vendor. Both of these options should be made available in the general settings.

<i>Release 2:</i> If Barrier Recording is selected in Stakeholder Interaction, the user will need to be able to record a macro of where they experienced a barrier and then send this onto the production department of the publishing company or the Microlink R&D department.	Release 2: 4. Barrier Recording	<i>Release 2:</i> This in app functionality suggestion is taken from Accessibility by Demonstration (Bigham <i>et al</i>, 2010). In this paper not only is a macro sent but so is open source software if required by the developer.

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User Activity: Academic or Student	Front End (Walkthrough Skeleton):	Backend/Server Side/Comment
While the etext is being processed by the Publisher, Sensus Access, RNIB Bookshare or Bespoke Service the user must be able to undertake further searches, such as an isolated search, if required. The user may also need to attend to document management.	Open Access Search? <i>eg. Project Gutenberg</i> Institute Search?: ACM ☒ IEEE ☐ Web of Science ☐ Not available ☐ <i>...etc.</i>	Once the inaccessible flag has been sent to the publisher the user would be in the etext Shelf and would be returned to this once the burger menu is left by the user.

Once the Publisher, Sensus Access, RNIB Bookshare or bespoke service has finished processing the required academic etext the user will need to receive a notification: <i>eg.</i> 'Your accessible PDF or ePub is available'. The user will need to be asked if they wish to download or transfer it. If yes, continue. If no, the user will need to be able to download/transfer it at a later stage in general settings.	NOTIFICATION: Your accessible PDF or ePub is available Download/Transfer to the cloud?	If there are multiple documents available this would also need to be in the form of a notification. This notification will need to appear during a search, in the etext shelf or using the eReading UI.

If Download/Transfer is selected in General Settings (Institute), the user would need to be able to download the PDF directly or transfer it to the cloud. The Publisher, RNIB Bookshare, Sensus Access or bespoke service would provide a link. The file can be downloaded or transferred to Dropbox, Google Drive, Datanywhere¹⁶ etc.	8. Download Local Transfer to the Cloud?	Datanywhere, from Varonis, could use the University of Southampton servers. For now Dropbox or Google Drive will need to be used for cloud storage. If 'local' is chosen then enable the user to download to their device. If transfer to the cloud is chosen then files need to be moved to Dropbox, Google Drive and/or Datanywhere respectively.
User Activity: Academic or Student	Front End (Walkthrough Skeleton):	Backend/Server Side/Comment
If Document Management is selected in General Settings (Institute), the user will need to be able to create new folders or delete local/cloud folders through a side swipe scrollable menu.	9. Document Management Create folders on device or in the cloud storage	If the user changes the file tree offline for cloud storage, the app will need to update the file tree when the app syncs online.

¹⁶ <https://www.varonis.com/products/datanywhere/>

<i>Release 2:</i> If Reference Manager is selected in General Settings (Institute), the user will need to be able to access a reference manager that not only controls references, but also annotations, bookmarks, highlights. In particular the app must also be able to allow the user to create audio annotations. The user will also need to be able to share annotations.	Release 2: 10. Reference Manager <i>eg. Audio Annotations</i> Share annotations	This will be required in release two of the Web app. Having a reference manager will also appeal to the majority of students rather than just the 4% of print impaired students in Higher Education (HE) in the UK. The app will need to be able to export to mainstream bibliographic managers such as Endnote, Mendeley, Zotero <i>etc.</i> Conversely it will need to be able to import from them as well.
If Manage/Library of Voices is selected in General Settings (Institute), the user will need to be able to access free voices such as Graham (Acapela). The user will also need to be able to purchase Microlink voices such as Nawars Arabic corpus.	11. Manage/ Library Voices: Free & Purchase	<i>Release 2:</i> Third party voices could also be purchased with a percentage taken by Microlink.

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When leaving General Settings (Institute) and once the etext has downloaded the user will need to be able to select the etext on the app shelf. When selected the etext automatically opens in the eReader UI. Reflow must automatically occur at this stage by default.	INSTITUTE BRANDED WEB APP: etext shelf (One Sample etext) <Select title>	Progress through each etext must be available to the academic or student in the etext shelf. The general settings burger menu will need to be available top left whether in the etext shelf or eReader UI.

User Activity: Academic or Student	Front End (Walkthrough Skeleton):	Backend/Server Side/Comment
Once the etext is opened in the eReader the user will need to be able to navigate or move focus through gestures for every option in a logical order. <i>Release 2:</i> The user will also need to be able to move from Chapter to Chapter through to character to character using the Previous and Next Buttons on the UI. This will require a granularity setting for the semantic structure of the eContent.	ONLINE The Microlink Web App (MWA) eReader User Interface (UI) (Institute)	The app will need to automatically reflow any imported mainstream format, such as PDF, ePub, Mobi, DocX, RTF and TXT. The Amazon AZW format requires manual parsing and is a low priority - release 3. An option to turn reflow on /off will also need to be available. The text on screen will need to be responsive and allow a maximum font size of 18pt (24px) (Luz Rello, 2014) for a small screen devices when online or offline. When online the app can sync with the server and can make any updates in the background. The (UI) in both the online and offline mode will be based on the Voice Dream UI, but with additional functionality. Please see the end of this document for an initial layout for the MWA eReader UI. The UI will also need a STEM Reader button on <i>Release 3</i>.

The user will need to receive a notification to use Text to Speech if the maximum font size on a small screen device is reached.	NOTIFICATION: You may wish to use Text To Speech (TTS)	So for example, if the maximum font size of 18pt (24px) is reached on a small screen device and the user keeps using gestures on screen to increase font size, then a notification stating that ‘you may wish to use TTS’ appears.
If offline functionality is required because connectivity is lost or deliberately prevented, the user will still need to be able to read the book they are currently in, with a temporary download or be able to access and read books stored on their device when in offline mode. For example when the device is in Airplane Mode.	OFFLINE The Microlink Web App (MWA) eReader User Interface (UI) (Institute)	When in offline mode, the user must still be able to record audible annotations through speech to text or by using a braille display, or other AT, connected to the device. <i>Release 2:</i> Will include a feature that helps the user when reading in direct sunlight or bright conditions for both the online and off line eReader UI.

User Activity: Academic or Student	Front End (Walkthrough Skeleton):	Backend/Server Side/Comment
The user will need to receive a notification stating what book is currently being read.	NOTIFICATION: Current book being read.	The notification should appear in the system tray at the top of the screen on a mobile device. This is to allow the user to remember what book is being read while using other apps. This is for both online and offline functionality.
If the imported document, such as a PDF, passes the basic accessibility check but is still inaccessible (Whitehouse, 2012), the user will need to be able to send the document to the publisher, RNIB Bookshare or bespoke service using an open field to explain their specific accessibility requirements.	<i>eg. PDF</i> PASSED CHECK but still inaccessible - Custom <SEND>	The publisher and HEI library need to be notified automatically. In this instance the HEI library may need to intervene. This also prevents the publisher from doing the barest minimum.

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On first login, and prior to using text customisation in the eReader, the user will need to be asked permission to temporarily store user preferences to the device – similar to web cookies.	Save Temporary User Preferences to device? Permissions Yes/No	If yes, continue. If no, the user will need to receive a further notification stating that their customisation settings will not be saved.
If Customisation is selected in General Settings (Institute), the user will need to be able to alter settings in the new functional categories.	12. Customisation: Navigation Viewing Screen Readability & Legibility Audio	In the institute search the user will also need to be able to, through a long press, be able to move the categories up and down. The app GTasks (Google Tasks for Android demonstrates this¹⁷). The functional categories obtained from the expert review in January 2016. The new categories to select from will be Navigation, Viewing Screen, Readability & Legibility and Audio.

¹⁷ https://play.google.com/store/apps/details?id=org.dayup.gtask&hl=en_GB

User Activity:	Front End	Backend/Server Side/Comment
Academic or Student	(Walkthrough Skeleton):	
If Navigation is selected, the user will then be able to alter the following settings: Menu Text Size Finding/Searching Touch Controls The user must also, through a long press, be able to move the sub settings up and down within a category, again this will need to be recorded by the UBA.	Navigation Settings: Menu Text Size Cutom Menus Finding/Searching Touch Controls Speech Recognition	The menu text size adjustment will aid navigation within and between each component of the framework, namely: Discovery, Metadata, eContent Format, eReader and eContent. Finding/Searching – user determined categories, or auto alphabetical menu lists to aid navigation. Touch Controls – customisation of touch functionality for navigation. Speech recognition will also be required so the user can control the UI experience hands free. So for example, next paragraph, stop, annotate <i>etc.</i> If a user is driving this may cause split attention.

If Viewing the Screen is selected, the user will then be able to alter the following settings: Zoom, Reflow, Colour Changes. Settings nested within Colour Changes include Background Colour, Font Colour and Saturation.	Viewing the Screen Settings: Zoom Reflow Colour Changes: Background Colour Font Colour Saturation	The user must also, through a long press, be able to move the sub settings and groups of nested settings up and down within a category, again this will need to be recorded by the UBA.

If Readability & Legibility are selected, the user will then be able to alter the following settings: - Style of Font - Font Size - Line Spacing - Margin Spacing - Overlay - Overlay Options - Font Colour - Full Screen Reading	Readability & Legibility Settings: - Style of Font - Font Size - Font Colour - Text Alignment - Line Spacing - Margin Spacing - Overlay - Overlay Options - Full Screen Reading	The user must also, through a long press, be able to move the sub settings and groups of nested settings up and down within a category, again this will need to be recorded by the UBA. Note: Font Colour is a duplicate setting, referred to as redundancy (Wechsung, 2014), whereby a user does not need to open two menu settings.

User Activity: Academic or Student	Front End (Walkthrough Skeleton):	Backend/Server Side/Comment
From within Readability and legibility, if Full Screen Reading is selected, the user will then be able to turn on and off readability. When in full screen mode, readability is by default set to ON. The Readability setting is taken from the app¹⁸ and used by ATbar¹⁹.	Full Screen Reading (Readability On/Off)	Readability declutters the screen and provides a more comfortable reading experience. Ensure this information is collected by the UBA, it will help determine if full screen reading is used over non-full screen reading. Also set media queries/features for reading such that landscape is for reading sentences, portrait for reading paragraphs.
If Audio is selected in General Settings (Institute), the user will then be able to alter the following settings: - Text to Speech - Rate of Speech - Pronunciation - Voice Library The user, through a long press, will be able to move the sub settings up and down within a category, again this will need to be	Audio Settings: Text to Speech Rate of Speech Pronunciation Voice Library Purchase Voices	It is important that the user still has access to the core functionality of the institute search audio settings, in particular pronunciation and voice library. The free version of the app must also provide in app purchases such as voices from Mircolink.

¹⁸ <https://play.google.com/store/apps/details?id=com.readability&hl=en>

¹⁹ <https://www.atbar.org/>

recorded by the UBA.		
If Sign Out & Close are selected in the General Settings (Institute), the user will need to be able to close the institute search at any stage and return where they left off after log in.	15. Sign Out & Close	If the user is downloading an etext, and there is temporary disconnection the app must automatically resume download on reconnection.

I.1.8 Academic publisher/academic aggregator general settings:

The following settings are an initial attempt at providing general settings for the academic publisher aspect of the web app. The settings relating to authentication, permissions, notifications and online/offline functionality will be integrated into a summarised version of the settings.

- **Tutorial & Help Documentation**
 - Quick Start
 - Full Walkthrough
 - Smart Notifications
 - Help Documentation
 - Turn On/Off
- **Branding App**
 - Templates
 - Import Corporate Stationery
- **Stakeholder Interaction**
 - Academic/Student Authentication
 - Sensus Access Authentication
 - RNIB Bookshare Authentication
 - Bespoke Services Authentication
 - *Demand*
 - Inaccessible Flag Requests
 - Status Reports
 - View
 - Update
 - Analytics
 - Visualise Data
 - Interrogate
 - *Validation*
 - PAVE (PDF)
 - ePub Checker
 - Pass Reports
 - Fail Reports
 - *Fixing*
 - PAVE PDF
 - Quickfixes
 - Document Settings
 - Document Content
 - *Testing* (Release 2)
 - eReader Testing
 - Disability Simulation
 - DRM Extension

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- Requests
 - Download Timeout
 - Upload/Send
 - Upload
 - Job Requirement (to Sensus Access, RNIB Bookshare, Bespoke Services)
 - Send
 - Accessible Document (to Academic or Student)
 - Publisher Lookup Ranking
- **eReaders Tested for Accessibility**
 - Web2Access Feed
-
- **Authentication**
- Registration
- Login
- Change User
-
- **Permissions**
- User Behaviour Analytics
 - Yes/No
- Cloud Storage
 - Datanywhere
 - Google Drive
 - Dropbox
- Temporary User Preferences
-
- **Notifications**
 - On/Off
-
- **Online/Offline Functionality**
-
- **STEM**

3.3. Academic publisher/academic aggregator user story

User Activity:	Front End (Walkthrough Skeleton):	Backend/Server Side/Comment
Academic publisher		
The user will need to be able to select a link from their desktop or software environment to the Web application.	Publishers/Aggregators Desktop or Software Interface	This is included to provide a context of where the web app will be used by Academic publishers. For example: IoP are trialling DigiEdit²⁰, an authoring tool, in their Production Department. IoP offshore typesetting to India. Penguin use a combination of Oxygen XML Editor²¹ and a link to the IDPF Online Validation Tool²² in a Digital Management Department. Small to Medium Enterprise (SME) Publishers would have a single Production department that does everything relating to book production. Adobe Indesign²³ and QuarkXpress²⁴ are used in publishing houses to export high resolution PDFs and ePubs that would require being checked for

²⁰ <http://www.pcquest.com/mps-digiedit-online-editing-tool-enables-seamless-collaboration-from-anywhere/>

²¹ <https://www.oxygenxml.com/>

²² <https://github.com/idpf/epubcheck>

²³ <http://www.adobe.com/uk/products/indesign.html>

²⁴ <http://www.quark.co.uk/Products/QuarkXPress/>

		accessibility.
On first login, the user will need to be able to select, from a notification, if they are an: Publisher HEI Library <i>(In this instance Publisher would be selected from the notification list.)</i>	NOTIFICATION Are you: Publisher/ Aggregator HEI Library?	Note: The option for HEI libraries will include librarians and/or disability officers. The notifications will need to appear in the device notification tray and drop down menu. Items in the drop down menu will need to be selectable.
On first login, the user will need to be able to register and/or login into the authentication process.	Authentication: Registration Login	The authentication referred to here is where publishers provide libraries access to copyright material based on the institute libraries subscription. Following this User Behaviour Analytics (UBA) permissions must be requested if a participant in a user study has logged on.

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User Activity:	Front End (Walkthrough Skeleton):	Backend/Server Side/Comment
Academic publisher		
After login the user will need to be able to view and navigate through the Publisher Web App user interface (UI).	Eg. Publisher Web App User Interface (UI)	The Publisher web app will require a left hand general settings menu for the laptop/desktop version of the app. Release 2: If a mobile web app version is made for the publisher side swipe scrollable menus will be required. The PAVE aspect of the app is currently not supported by screens smaller than 10 inches.
On first login, the user will need to be asked for permission for UBA to be collected. For now this feature will only be made available to participants who are given a participant login user name and password.	USER BEHAVIOUR ANALYTICS (UBA): Permissions Yes/No	If yes, continue. If no, then the general setting for UBA must be greyed out and not be functional. This is crucial for ethics approval.
On first login, the user will then need to receive an additional notification asking: 'Do you require a quick start tutorial?'	NOTIFICATION: Do you require a quick start tutorial? Yes/No?	If, yes the user will need to be provided with a quick start tutorial. If no, the user will need to be returned to the academic publisher UI for this app.

The user will need to be able to undertake a quick start tutorial that provides essential information about using the web application.	QUICK START TUTORIAL (Basic – Release 1) <continue>	If continue, then the user is returned to the publishers UI. The UI for the publisher will need to be viewed on desktop/laptop machines. In addition to this the publisher may need to view the UI while on the move through a mobile version. The PAVE accessibility evaluation tool will only be able to be used on a screen no smaller than 10 inches, for now.
The quick start tutorial will also need to introduce the Full Walkthrough Settings, Smart Notifications, Help Documentation and Turn On/Off Tutorial Mode to the user.	Quick Start: Full Walkthrough Smart Notifications Help Documentation Turn On/Off	Full Walkthrough, offers the user a complete tutorial for every aspect of the app through notifications. Smart Notifications, based on detecting user tactics , are notifications that only appear when the user appears to be struggling. Detailed accessible help documentation should be available on demand. The final option is to allow the user to turn the tutorial mode on/off.

User Activity:	Front End	Backend/Server Side/Comment
Academic publisher	(Walkthrough Skeleton):	
When in the publisher UI, the user will need to be able to view and select one of the following five options: 1. Tutorial & Help Documentation 2. Branding App 3. Stakeholder Interaction 4. eReader Accessibility 5. Sign Out	GENERAL SETTINGS 1. Tutorial & Help Documentation 2. Branding App 3. Stakeholder Interaction 4. eReader Accessibility 5. Sign Out	The Branding App option enables the publisher to brand their own app in-house, according to corporate identity guidelines using templates within the app. The Stakeholder Interaction provides additional options for the user to engage with other stakeholders. The eReader Accessibility option, driven by Web2Access, will enable the Publisher to test their PDF or ePub on other eReaders and to be aware of other eReader platforms.

If Tutorial & Help is selected in General Settings, the user will need to be provided with five side menu options, namely: Quick Start Full Walkthrough Smart Notifications Help Documentation Turn On/Off	Tutorial & Help: Quick Start Full Walkthrough Smart Notifications Help Documentation Turn On/Off	The quick start option provides the user with only essential tutorials to get up and running quickly in a busy working environment. Full Walkthrough, however, offers the user a complete tutorial for every aspect of the app through notifications. Smart Notifications, based on detecting user tactics, are notifications that only appear when the user appears to be struggling. Detailed accessible help documentation should be available on demand. The final option is to allow the user to turn the tutorial mode on/off.
<i>Release 3:</i> If Branding App is selected in the General Settings, the user will need to be able to brand the app according to the publishers corporate identity using templates within the app.	Release 3: Branding App to Publishers Corporate Identity	The publishers logo and corporate colours will need to be provided by the publishers design studio or press release pack. The options will need to be accessed from a burger menu if on a mobile or from a left hand menu on a laptop/desktop.

User Activity:	Front End	Backend/Server Side/Comment
Academic publisher	(Walkthrough Skeleton):	
If Stakeholder Interaction is selected in General Settings, the user will need to be able to select the burger menu on a mobile device or just have eight options available on a left menu, namely: 1. Authentication 2. Demand 3. Validation 4. Fixing 5. Testing (<i>Release 2</i>) 6. Digital Rights Management (DRM) Extension 7. Upload/Send 8. Publisher Lookup (PL) Ranking	STAKEHOLDER INTERACTION: 1. Academic/Student Authentication 2. Demand 3. Validation 4. Fixing 5. Testing (<i>Release 2</i>) 6. DRM Extension 7. Upload/Send 8. Publisher Lookup Ranking	The Authentication option allows the user to determine if an academic or student is authorised to receive etexts. The Demand option provides data relating to inaccessible flag requests from both academics and students. Validation enables PDFs (including online PDFs) and ePubs to be checked for accessibility prior to release. Fixing enables PDFs and ePubs to be made accessible. Currently, however, PAVE does not provide an option for a URL to a PDF to be checked or fixed. Testing will provide the means to simulate disabilities, such as colour blindness, and to test documents within a publishers version of the eReader UI - this is marked for <i>Release 3</i>. DRM Extension Upload/Send will provide the option to upload to Sensus Access, RNIB Bookshare, Bespoke Services or to send the file direct to the academic or student. PL Ranking or Publisher Lookup Ranking will enable the publisher to see how they rank compared to other publishers for accessibility.

If Academic/Student Authentication is selected in Stakeholder Interaction, the user will need to be able to establish that the academic or student is legitimately at the institute.	Academic/Student Authentication: Yes/No	This will only allow the publisher to view a check sum unique ID of the academic/student that is issued by the HEI library, identifying the academic/student as enrolled at the institute. If yes, continue. If no, the academic or student is not authorised to receive etexts.
On first login, the user will need to be able to establish that the library has authorised the academic/student to send a publishers file direct to Sensus Access.	Library Authentication Sensus Access Approved Yes/No?	If yes, then continue. If no, then a request for approval will need to be automatically sent through to the library and receipt of this sent back automatically to the publisher. If there is a problem the library will need to contact the publisher directly.

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User Activity:	Front End	Backend/Server Side/Comment
Academic publisher	(Walkthrough Skeleton):	
On first login, the user will need to be able to establish that the library has authorised the academic/student to send a publishers file direct to RNIB Bookshare.	Library Authentication RNIB Bookshare Approved Yes/No?	If yes, then continue. If no, then a request for approval will need to be automatically sent through to the library and receipt of this sent back automatically to the publisher. If there is a problem the library will need to contact the publisher directly.
If Demand is selected in Stakeholder Interaction, the user will need to be able to choose from three options, namely: Inaccessible Flag Requests Status Report Analytics	Demand: Inaccessible Flag Requests Status Reports Analytics	The inaccessible flag requests from academics/students will need to include verbose audits. The status reports provide a summary of the audit. Analytics offers the publisher the means to be able to visualise or interrogate the demand data. This data can be escalated to the Board of Directors and/or the Publishers Association.

If Inaccessible Flag Request is selected in Demand, the user will need to be able to view and respond to inaccessible flags requested by academics or students.	Inaccessible Flag Requests	The inaccessible flags are those requests sent back to a publisher where a PDF or ePub has failed a basic accessibility check in app. There may also be instances where the PDF or ePub has passed a basic accessibility test but still may not meet the academic/students accessibility requirements. The inaccessible flags will provide data about demand. This data will also help establish priorities for demand. So for example, if 1000 students request a particular publication that is inaccessible, over one student who selects another publication, the demand is clear and so a priority can be set for the 1000 students.

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If Status Reports is selected in Demand, the user will need to be able to view a summarised version of the audit for inaccessible flag requests. The user will also need to be able to update the audit either manually or automatically.	Status Reports View Update	The audit is integral to the tripartite relationship between the publisher, the library and the academic/student. Any stakeholder in this relationship must be able to view the audit. So for example, if work is being undertaken on an inaccessible PDF or ePub by the publisher, this needs to be indicated in the audit to the library and the academic/student.
User Activity: Academic publisher	Front End (Walkthrough Skeleton):	Backend/Server Side/Comment
If Analytics is selected in Demand, the user will need to be able to visualise the audit data based on the stakeholders activity. The user will also need to be able to interrogate the data.	Analytics: Visualise Data Interrogate	The interrogation of data might include a list of universities in the UK indicating the highest demand for specific inaccessible publications. So for example, Cambridge might have a high demand for Physics whereas Oxford might have a high demand for English Literature.

If 'Validation' is selected in Stakeholder Interaction, the user will need to be able to check a PDF or ePub using PAVE for PDF and/or ePubChecker for ePubs. The user will also need to be able to view pass and fail reports.	3. Validation: Automated tool PAVE (PDF) ePub Checker Pass Reports MWS Accessibility evaluation tool.	The PAVE and ePub checker tools provide a thorough evaluation of the document. The basic check at the academic/student end is to field for Small to Medium Enterprise (SME) Publishers who do not yet have access to PAVE or ePubChecker, and/or who might not be aware of accessibility. If an inaccessible flag is received from an academic/student the PDF or ePub can be re-introduced into the checking process at this stage, by the user, if required.
If Pass Reports in Validation is selected, the user will need to be able to view pass reports and be enabled to send a document directly to the academic/student.	Pass Reports <Send>	A summarised version of the pass report will need to be sent automatically with the etext to the academic or student. <i>Release 2:</i> It may be possible to automate this process, whereby the instant a PDF or ePub is passed, it can be sent to the academic or student automatically.

If Fail Reports is selected in Validation, the user will need to be able to view fail reports and then to be able to select single or multiple titles to be fixed in priority order.	Fail Reports <Fix>	PAVE provides a means to fix inaccessible PDFs. No 'fixer' is available, as yet, for ePubs. This will need to be developed in-house and based on the accessibility fixer in Power Point. This walks the user through fixing accessibility barriers encountered.
If the document is a PDF, the user will need to be able to use the PAVE tool. If the document is an ePub, the user will need to be able to use ePubchecker.	eg. PAVE (PDF) Walkthrough 'Fixer'	If multiple documents are selected in the Fail Report, the PAVE and ePubChecker tool will need to be activated respectively when required. The walkthrough will ensure no stage is missed.

User Activity:	Front End (Walkthrough Skeleton):	Backend/Server Side/Comment
Academic publisher		
The PAVE (PDF) Checker and Fixer enables the user to check and fix imported PDFs.	eg. PAVE (PDF) Walkthrough 'Fixer' Quickfixes Document Settings Document Content	PAVE provides a simple or detailed accessibility report. The simple report highlights Quickfixes that PAVE was automatically able to correct. The simple report also checks document settings and document content for accessibility.
PAVE also enables the user to be able to tag PDFs for accessibility.	PDF Tagged for Accessibility?	This information must be available in the PDFs metadata, so that the basic check at the academic/student end is able to detect it.
PAVE also enables the user to be able to fix headings within the PDF.	PDF Headings?	The title of an academic paper is usually 'H1' and then subsequent headings 'H2' for the abstract, introduction, methodology, results, discussion and conclusion. In some cases 'H3' is used for sub sections.
PAVE also enables the user to be able to fix Alt Text for images.	PDF Alt Text?	It is here that a notification about the difference between a caption and alt tag description will be required.

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On first login, the user will need to receive a notification about the difference between a caption and an alt tag description.	NOTIFICATION Caption vs Description	For example, alt tags must not contain the word 'image'. It is also unlikely that the wording for a caption will be suitable for an alt tag description. Facebook are using artificial intelligence to attempt to describe images ²⁵ , this would be in release 4 or later.
PAVE also enables the user to be able to fix tab order for links.	PDF Tab Order?	Tab ordering is necessary, particularly when using a screen reader. This allows the reader to tab from one link to another.

²⁵ <http://uk.businessinsider.com/facebook-ai-artificial-intelligence-automatically-describe-photos-blind-people-accessibility-2016-4>

User Activity:	Front End	Backend/Server Side/Comment
Academic publisher	(Walkthrough Skeleton):	
PAVE also enables the user to be able to alter the reading order manually.	PDF Reading Order? (Manual)	The PAVE website does suggest that a screen smaller than 10 inches might cause confusion when trying to use PAVE. This part of the app will need to be used on a laptop or desktop screen. Release 3: Pre-defined reading orders can be set based on house style. Once completed the walkthrough moves onto Digital Rights Management.
If DRM Extension is selected from Stakeholder Interaction or once the PAVE PDF fixing has taken place, the user will need to be able to alter Digital Rights Management (DRM) download timeouts and restrictions.	6. Digital Rights Management (Release 2) PDF/ePub DRM Extension? Yes/No	If Yes, the user will be taken to options that will allow them to alter DRM Options. If no, existing DRM remains unaltered. and the user is taken to the insertion of STEM content - for release 3; or to an option to upload to Sensus Access, RNIB Bookshare or Bespoke Service; or send the document directly to the academic or student. Note: IoP and O'Reilly have removed DRM protection from all their titles. Unfortunately, DRM, looks set to be with the Publishing industry for the foreseeable future, unless DRM legislation is altered, or, as with IoP and O'Reilly, publishers are willing to remove it.

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<i>Release 3:</i> The user will then need to be able to add complex document content, such as MathML or ChemML. The user will then need to be able to send the document.	Release 3 Walkthrough ePub: STEM, Mathjax, MathML, ChemML	<i>Release 3:</i> In this release the user will need to have a walkthrough for the injection of MathML or ChemML into complex documents.
If Upload/Send is selected, the user will need to be able to select whether they need to upload a document to: RNIB Bookshare or a bespoke service. Or send the document directly to an Academic or Student.	7. Upload: RNIB Bookshare? Bespoke? Send: Academic Student?	In order to be able to do this the publisher will need to write a job requirement. Alternatively the publisher will need to be able to send documents directly to students based on their unique ID.

User Activity:	Front End (Walkthrough Skeleton):	Backend/Server Side/Comment
Academic publisher		
For example, if Bespoke is selected in Upload, the user will need to be able to create job requirements that are sent directly to bespoke sheet music services.	Job Requirement: <i>eg. Bespoke: Sheet Music</i>	Once received, the bespoke service must automatically provide an electronic receipt, so as to maintain an audit trail.
If Student is selected in Send, the user will need to be able to send a document directly to the student. Once the document has been sent the user will need to be returned to the publisher UI.	Send Direct to Student <continue>	Based on the unique student ID, Authentication from the HEI Library needs to be undertaken automatically. If a problem occurs a message from the library needs to be automatically sent to the publisher.
If Publisher Lookup Ranking is selected in Stakeholder Interaction, the user will need to be able to access the Publisher Lookup Ranking.	Publisher Lookup Ranking	Although RNIB Bookshare (formerly Load2Learn) currently oversees Publisher Lookup, JISC is working on an alternative ²⁶ .

²⁶

<https://docs.google.com/forms/d/1TV7156FrEjvHz0QLCzyPQiTLOPC2268QgPEB1Xay5tg/prefill?pref=2&pli=1>

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If eReader Accessibility is selected in General Settings, the user will need to be able to access the Web2Access data relating to the eReaders that have been tested for accessibility.		This would require a feed from Web2Access. The Microlink Web App eReader would need to be included.
If Sign Out is selected in General Settings, the user will need to be able to Sign Out of the web application and close the web app at any stage and return to where they left off.		If the User Behaviour Analytics was activated, a UBA log will need to be sent automatically sent to the publishers marketing department, and here to the research department at the University or to Microlinks R&D department.

I.1.9 HEI librarians general settings:

The following settings are an initial attempt at providing general settings for the HEI Library aspect of the web app. The settings relating to authentication, permissions, notifications and online/offline functionality will be integrated into a summarised version of the settings.

- **Tutorial & Help Documentation**
 - Quick Start
 - Full Walkthrough
 - Smart Notifications
 - Help Documentation
 - Turn On/Off
- **Branding Library App**
 - Templates
 - Import Corporate Stationery
- **Sensus Access Administration**
 - Incoming
 - Outgoing
- **Stakeholder Interaction**
 - Branding Institute App
 - Templates
 - Import Corporate Stationery
 - Deploy
 - Authenticate Academic or Student
 - Authenticate for Sensus Access
 - Authenticate for RNIB Bookshare
 - Authenticate for Bespoke Service
 - Inaccessible Flags
 - Academic Orders
 - DRM Extension
 - Publisher Requests
 - Publisher Lookup Ranking
- **Legacy**
 - Alert
 - Import
 - Send
 - Legacy Watched Folders
 - Setup
 - Send
 - Academic
 - Student
- **eReaders Tested for Accessibility**

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- Web2Access Feed

➤ **Authentication**

- Registration
- Login
- Change User

➤ **Permissions**

- User Behaviour Analytics
 - Yes/No
- Cloud Storage
 - Datanywhere
 - Google Drive
 - Dropbox
- Temporary User Preferences

➤ **Notifications**

- On/Off

➤ **Online/Offline Functionality**

3.5. HEI Librarians user story

User Activity:	Front End	Backend/Server Side/Comment
HEI Library	(Walkthrough Skeleton):	
The user will need to be able to select a link from their desktop or software environment to the Web application.	Librarian or Disability Officer Desktop or Software Interface	Libraries use a resource discovery tool to direct users to the required eBook platform and so does not include searching and results pages. This is where this app has an advantage at the Academic or Student end.
On first 'login', the user will need to be able to select, from a notification, if they are an: Publisher HEI Library <i>(In this instance HEI Library would be selected from the notification list.)</i>	NOTIFICATION Are you an: Publisher HEI Library?	Note: The option for HEI libraries will include both librarians and/or disability officers. The notifications will need to appear in the device notification tray and drop down menu. Items in the drop down menu will need to be selectable.

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On first login, the user will need to receive a notification about registration and then be able to register through the HEI libraries authentication process. Once registered and logged on the user will need to be asked for User Behaviour Analytics permissions.	INSTITUTE LOGIN Authentication: Registration Login	Registration would need to be taken from a global login for all authenticated academic search engines subscribed to by the HEI Library.
After login the user will need to be able to view and navigate through the HEI Library Web App user interface (UI).	HEI Library User Interface	The HEI library web app will require a left hand general settings menu for the laptop/desktop version of the app. Release 2: If a mobile web app version is made for the HEI library, side swipe scrollable menus will be required.
If HEI library is selected, the user will need to be asked for permission for User Behaviour Analytics (UBA) to be collected. For now this feature will only be made available to participants who are given a participant login user name and password.	USER BEHAVIOUR ANALYTICS (UBA): Permissions Yes/No	If yes, continue. If no, then the app setting for UBA must be greyed out and not be functional. This is crucial for ethics approval.

User Activity:	Front End (Walkthrough Skeleton):	Backend/Server Side/Comment
HEI Library		
On first login, the user will then need to receive an additional notification asking: 'Do you require a quick start tutorial?'	NOTIFICATION: Do you require a quick start tutorial? Yes/No?	If, yes the user will need to be provided with a quick start tutorial. If no, the user will need to be returned to the librarian or disability officers UI for this app.
The user will need to be able to undertake a quick start tutorial that provides essential information about using the web application.	QUICK START TUTORIAL (Basic – Release 1) <continue>	If continue, then the user is returned to the HEI library UI. The UI for the HEI Library will need to be viewed on desktop/laptop machines. In addition to this the library may need to view the UI while on the move through a mobile version such as a tablet.
The quick start tutorial will also need to introduce the Full Walkthrough Settings, Smart Notifications, Help Documentation and Turn On/Off Tutorial Mode to the user.	Quick Start: Full Walkthrough Smart Notifications Help Documentation Turn On/Off	Full Walkthrough, offers the user a complete tutorial for every aspect of the app through notifications. Smart Notifications, based on detecting user tactics , are notifications that only appear when the user appears to be struggling. Detailed accessible help documentation should be available on demand. The final option is to allow the user to turn the tutorial mode on/off.

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The user will need to be able to select one of the following seven options, available through a side menu, namely: 1. Tutorial & Help Documentation 2. Branding Library App 3. Sensus Access Administration 4. Stakeholder Interaction 5. Legacy 6. eReader Accessibility 7. Sign Out	General Settings: 1. Tutorial & Help Documentation 2. Branding Library App 3. Sensus Access Administration 4. Stakeholder Interaction 5. Legacy 6. eReader Accessibility 7. Sign Out	The tutorial & help option is hopefully self-explanatory, providing the user with options from quick start guides through to being able to turn the tutorial mode on and off. Stakeholder interaction will provide the HEI library with options relating to publishers and the inaccessible flags that academics/students have sent. The Branding App option enables the user to brand the app to the institutes corporate identity.

User Activity: HEI Library	Front End (Walkthrough Skeleton):	Backend/Server Side/Comment
If Tutorial & Help Documentation is selected in General Settings, the user will need to be provided with five side menu options, namely: Quick Start Full Walkthrough Smart Notifications Help Documentation Turn On/Off	1. Tutorial & Help Documentation: Quick Start Full Walkthrough Smart Notifications Help Documentation Turn On/Off	The quick start option provides the user with only essential tutorials to get up and running quickly in a busy working environment. Full Walkthrough, however, offers the user a complete tutorial for every aspect of the app through notifications. Smart Notifications, based on detecting user tactics, are notifications that only appear when the user appears to be struggling. Detailed accessible help documentation should be available on demand. The final option is to allow the user to turn the tutorial mode on/off.
If Branding Library App is selected in General Settings, the user will need to be able to brand the HEI Library Web App for in house use.	2. Branding Library App	The library will be able to use templates provided in app to brand their own app. <i>Release 3:</i> In time the Print Centre at the HEI library would be given access to the app and responsibility for branding the HEI Library user interface of the app.

If Sensus Access is selected in General Settings, the user will need to be able to be able to access the Administration side of Sensus Access.	3. Sensus Access Administration	This is where maintenance, house-keeping and monitoring can be undertaken for Sensus Access.

User Activity: HEI Library	Front End (Walkthrough Skeleton):	Backend/Server Side/Comment
If Stakeholder Interaction is selected in General Settings, the user will need to select one of the following eleven options: 1. Branding Institute App 2. Authenticate Academic or Student 3. Authenticate for Sensus Access 4. Authenticate for RNIB Bookshare 5. Authenticate for Bespoke Service 6. Inaccessible Flags 7. Academic Orders 8. DRM Extension 9. Publisher Lookup (Ranking)	4. Stakeholder Interaction: 1. Branding Institute App 2. Authenticate Academic or Student 3. Authenticate for Sensus Access 4. Authenticate for RNIB Bookshare 5. Authenticate for Bespoke Service 6. Inaccessible Flags 7. Academic Orders 8. DRM Extension 9. Publisher Lookup (Ranking)	Branding the institute eReader app will need to be undertaken by the library and then made available to academics and students. This will be done using simple in app templates. New Publishers are those that provide educational publications but are not as yet subscribed to by the library. This is where allowing the academic to order accessible digital content would be made available. Authenticated publishers are those that the library subscribes to and have authorised to use Sensus Access, RNIB Bookshare, Bespoke Services and for academics/ students to receive etexts directly. Inaccessible flags include an audit that can be seen by the publisher, academic and student stakeholders. Authenticate Academic or Student is where the HEI library provides Shibboleth or Athens authentication to the student. Publisher Lookup Ranking is made available via RNIB Bookshare (formerly Load2Learn).

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<i>Release 3:</i> If Branding App is selected in Stakeholder, the user will need to be able to brand the app, with the institutes corporate identity, for the app to be used by academics and students.	Release 3: 1. Branding App to Institutes Corporate Identity	The library will provide the institute eReading app and will therefore need to be responsible for the branding of both the guest and institute version of the app. <i>Release 3:</i> The print centre in the library would need to provide suitable graphics that can be inserted by the library into templates available in the web application. <i>Release 4:</i> The Library Print Centre would need to have access to the app so that branding can be controlled directly by that department.

User Activity: HEI Library	Front End (Walkthrough Skeleton):	Backend/Server Side/Comment
If Authenticate Academic or Student is selected in Stakeholder Interaction, the user will need to be able to provide Shibboleth or Athens authentication for the academic or student.	2. Authenticate Academic or Student: Yes/No	If yes, continue. If no, the academic or student is not authorised to receive etexts from the publisher.
If Authenticate for Sensus Access is selected in Stakeholder Interaction, the user will need to be able to authorise the student to send a publishers file direct to Sensus Access.	3. Authenticate for Sensus Access Approved Yes/No?	If yes, then continue. If no, then the publisher will need to be automatically notified. If there is a problem the publisher will need to contact the HEI library directly.
If Authenticate for RNIB Bookshare is selected in Stakeholder Interaction, the user will need to be able to authorise the publisher to send a publishers file direct to RNIB Bookshare.	4. Authenticate for RNIB Bookshare Approved Yes/No?	If yes, then continue. If no, then the publisher will need to be notified from RNIB Bookshare and the HEI Library kept in the loop. If there is a problem the publisher will need to contact RNIB Bookshare directly.

If Authenticate for Bespoke is selected in Stakeholder Interaction, the user will need to be able to authorise the publisher to send a publishers file direct to a Bespoke Service, such as making sheet music accessible.	5. Authenticate for Bespoke Approved Yes/No?	If yes, then continue. If no, then the publisher will need to be notified from the Bespoke Service and the HEI Library kept in the loop. If there is a problem the publisher will need to contact the Bespoke Service directly.
If Inaccessible Flags is selected in Stakeholder Interaction, the user will need to be able to view a report page of all inaccessible flags sent to publishers, starting with most current first.	6. Inaccessible Flags from Academic or Student to Publisher	<i>Release 2:</i> The user will also need to be able to interrogate inaccessible flags being sent to publishers.
If Academic Orders is selected in Stakeholder, the user will need to be able to view all orders made by academics for accessible ePublications.	7. Academic Orders	The academic orders may be for a greater number of existing digital versions being given access; or this is where the academic will be able to suggest accessible academic material the HEI library is not currently subscribed to.

User Activity: HEI Library	Front End (Walkthrough Skeleton):	Backend/Server Side/Comment
If DRM Extensions is selected, the user will need to be able to view DRM extensions authorised by the publisher for academics and students. The user will also need to be able to request DRM Extension from the publisher.	8. DRM Extensions for Student/Academic Sent to Publisher	loP and O'Reilly have removed DRM protection from all their titles. Unfortunately, DRM, looks set to be with the Publishing industry for the foreseeable future, unless DRM legislation is altered, or, as with loP and O'Reilly, publishers are willing to remove DRM.

If Publisher Lookup Ranking is selected in Stakeholder Interaction, the user will need to be able to access the Publisher Lookup Ranking.	9. Publisher Lookup Ranking	Although RNIB Bookshare (formerly Load2Learn) currently oversees Publisher Lookup, JISC is working on an alternative²⁷.

²⁷ <https://docs.google.com/forms/d/1TV7156FrEjvHz0QLCzyPQiTLOPC2268QgPEB1Xay5tg/prefill?pref=2&pli=1>

If Legacy is selected in General Settings, the user will need to be able to view all currently available documents. The user must also be able to receive an alert notification if an OCR, ICR, and legacy document transcription or scanning is available for an academic or student that has been specifically requested.	GENERAL SETTINGS 5. LEGACY NOTIFICATION: Alert	Alternatively, if a legacy document has already been processed this should be made available as any other library content. The notification will need to be made available regardless of where the user is on the Web App.
If an alert from OCR, ICR, Transcription or Scanning is received, the user will need to be able to import the document into the app and send it to the academic/student.	Alert: Import Send	The alerts will be triggered by the contents of a watched folder. Watched folders are 'watched' by systems that automatically process or alert as to their contents.
If Import is selected in Alert, the user will need to be able to import the contents of the watched folder into the web app.	Legacy Watched Folders: Setup	<i>Release 2:</i> This process could be automated, so that all available documents are automatically imported to the application when online.

Appendix I: Specification for a web service and four separate web applications

User Activity:	Front End (Walkthrough Skeleton):	Backend/Server Side/Comment
HEI Library		
If setup is selected in Legacy Watched Folders, the user will need to be able to setup options for the watched folders.	Watched Folders Setup	This would also include setting up the destination of files in the app. So, for example, if an academic had ordered an accessible version of a legacy document, the unique ID of the request makes the file automatically available to the academic/student group.
<i>Release 1:</i> If Send is selected in Alert, the user will need to be able to manually send the document to the academic or student until such time as an automated version becomes available.	Send: Academic Student?	<i>Release 2:</i> The automated process to make the digital version of the legacy file available to the academic/student will need to be developed.
If eReader Accessibility is selected in General Settings, the user will need to be able to access the Web2Access data relating to the eReaders that have been tested for accessibility.	GENERAL SETTINGS 6. Ereaders tested for accessibility	This would require a feed from Web2Access. The Microlink Web App eReader would need to be included. <i>Release 2:</i> Will need to provide a means to the HEI Library to also gather device information from the academic or student user.

If Sign Out is selected in General Settings, the user will need to be able to logout of the web application and/or close the web app and be able to return to where they left off.	GENERAL SETTINGS 7. Sign Out and Closing	If the User Behaviour Analytics was activated, a UBA log will need to be sent automatically to the Policy and Strategy Forum Accessibility Task and Finish Group, this would also need to include the research department.

I.1.10 Summary

The main outcome of the MWS and multiple web app specification is the impact the academic publisher can have on embedding accessibility at source, particularly in terms of using authoring software such as DigiEdit, enabling the publisher and the author to work in sync when providing content for electronic publications. By allowing the publisher to then immediately check for accessibility with the MWS, backed by accessibility experts overseeing the development of the web app, a seamless integration into the publisher's workflow can take place.

Furthermore, if issues are encountered by the end user, namely the academic or student, the UI enables the user to send an inaccessible flag back to the publisher triggering a process that fixes and then, in later releases of the app, would enable the publisher to test the final document. This can then be resent back to the user. An additional feature of the web app is that at the academic/student end an automatic accessibility check is also rapidly undertaken, fielding for Small to Medium Enterprise (SME) publishers who are not may not be aware of accessibility or have limited resources available – perhaps those in emerging economies. More importantly, an additional component enables the end user to still provide an inaccessible flag to the academic publisher even if an electronic document passes the basic accessibility check, this prevents academic publishers from producing the barest minimum required.

The most predominant feature of the web apps will be their ability to provide Stakeholder Interaction between the Academic publisher, the HEI Library and the Academic/Student in three separate web applications. The publisher will benefit in the following ways, enabling monetisation of the MWS:

- Data relating to the demand of inaccessible electronic documents.
In doing so this data will also help establish the priority of demand. So for example, if 1000 inaccessible flags are requested for a particular document over another single request for a document, the priority is clear.
- The means to quickly fix accessibility issues.
- The ability to promote their own titles similar to those downloaded by the user.
- Valuable research data for the marketing departments in publishing houses.

- Access to Publisher Lookup Ranking in one place.
- Accessible devices tested by experts through a feed from Web2Acces that can be resold by Microlink to be promoted through the publishers marketing channels.
- An Ereader that the publisher can be confident the accessible format they provide will not be made inaccessible by the Ereader.
- Customisation of electronic content for the academic or student user.

Simplification of the user interface:

Newell²⁸ recommends that the user interface needs to be simplified. VoiceDream has 11 functions on the main reading area. Mainstream mobile apps have 3 to 6 functions on the main screen.

²⁸ NEWELL, A. F. 2011. *Design and the Digital Divide: Insights from 40 Years in Computer Support for Older and Disabled People*, California, Morgan & Claypool. Page 102.

Published Articles

The following papers were written by the researcher and published for different conference proceedings. The 2016 paper was written as a result of the findings, in part, from Expert Review One. The 2014 paper was written just prior to beginning the doctorate and encapsulated research undertaken during a masters by research in 2011-2012.

1. ROGERS, N., WALD, P. M. & DRAFFAN, E. A. 2016. Evaluating the mobile web accessibility of electronic text for print impaired people in higher education. Proceedings of the 13th Web for All Conference. Montreal, Canada: ACM.
2. ROGERS, N., WALD, M. & DRAFFAN, E. A. 2014. Classic Accessibility Checks Fail eReaders. IFLA's WLIC 2014 Satellite Conference. Université Pierre et Marie Curie, Paris: BrailleNet and UPMC Sorbonne Universités.

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