Preferences for Global Access:

Profile Creation Support for Cloud-Based Accessibility

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Executive Summary

This report is part of the Preferences for Global Access (PGA) project, which seeks to enable systems that support the digital inclusion of all individuals experiencing disabilities, through the creation, refinement, communication, storage and interoperable recognition of user needs and preference profiles.

This work is centered on the assumption that access to information and communication technology (ICT) is a necessity, not an option. There is widespread agreement that current approaches to providing access for digitally excluded users, including users with disabilities, are not sufficient. As such, this report seeks to inform the development of appropriate "preference setting" tools that will help individuals learn about and easily experiment with content transformations and user interface reconfigurations that may make the content or service they are accessing easier to use or to understand.

Scope

The information in this report was developed through research that included a literature review and a compilation of examples of preference approaches, sets and mechanisms. The project's subject-matter experts utilized the findings of this research to extend and support their understanding and experience in the field and together began to articulate problems of access and barriers to entry as well as to debate and develop the most effective ways to approach defining and presenting preference specifications. The conclusions of these discussions form the jumping off point for possible design solutions that will be prototyped, tested, and presented in subsequent phases of the project.

Framing the Problem

More and more of our daily activities are mediated in some way by digital technology: point-of-sale devices, self-service kiosks, Internet-based services, interpersonal communication, appointment booking, DVRs, etc. Access to these technologies is critical for full participation in commercial, cultural, recreational and social activities.

For users with disabilities, the solution to access has largely been through assistive technology (AT) systems determined through assessments by clinicians, specialists or assistive technology vendors. Many individuals with disabilities do not have access to assistive technology assessment services due to location or other factors such as cost. Even when these services are available and users are prescribed assistive technologies, there are numerous shortcomings as identified in the literature:

1. ATs are not updated as regularly as other software, leaving users with outdated and unsupported technology options;
2. the prescribed AT system often matches a diagnostic classification rather than an individual's actual needs and requirements;

3. users have few opportunities to spend time with AT specialists learning how to use or configuring settings to use ATs independently, and as a result, users acquire systems that they do not understand or cannot use independently;
4. AT systems are usually expensive and out of reach for many low-income individuals;
5. most AT systems are available in only one context such as home or work but users encounter technology in every facet of daily life and are without AT;
6. the current system of accommodation ignores segments of the population who are not disabled but could benefit from alternative access due to contextual factors (such as a noisy environment, broken headphones, or temporary a disability such as a sprained wrist).

The result is that many users express dissatisfaction with their AT systems (Mann et al., 1993; Hastings Kraskowsky & Finlayson, 2001; Fisk et al., 2009, Lenker et al., 2013), and many report underutilizing or abandoning their systems altogether (Reimer-Weiss & Wacker, 2000; Scherer et al., 2005). Users who cannot afford an AT system or have poor access to these resources must do without or rely on the help of others (Copley & Ziviani, 2004). The need for global access thus becomes central; users move through a technology-filled world—the solutions for access need to be as mobile and context-independent as the people who use them, and as ubiquitous as the technologies they seek to access.

Access through Functional not Medical Descriptions

An important way to deliver access to ICT services is to provide a mechanism for users to modify and interact with the service through an interface that matches their individual needs and preferences. One approach to providing access has been to create a few interface subsets for specific disabilities: If users are blind then pictures are replaced with text, and if they use alternative controllers (no mouse), keyboard navigation is active. This “medical model” approach fails to recognize the heterogeneity of individuals with disability and fails to recognize that access issues arise for multiple reasons: context, technology failure, access device, temporary injury and permanent disability. Accessibility that solves for “problem users” is not inclusive and only provides good solutions for individuals whose problems can be described as stereotypical.

Inclusive design places the accessibility problem within the design; an interface that a user cannot access indicates a *failure of the design* to match the functional needs and preferences of the user. There is no assumption that images are not required because a user is blind. Instead, users can set their preferences as is appropriate for their visual acuity and methods of access (e.g., magnification, screen reader, or braille display). This functional approach to access is through personalized or “one-size-fits-one” accessibility, acknowledging the diversity of users and the full set of factors that may influence accessibility and matching the design to the individual needs of the user.

The Challenge: Creating Preference Settings that Anyone can Utilize

There is a real need to consider how users who do not feel at ease with technology and do not have the benefit of a tech-savvy helper will be able to engage in a preference setting dialogue. Development of a mechanism to bring preference setting to the user in an unobtrusive but helpful way is an important problem to solve. Enabling users to explore preferences and to learn how to improve their experience with technology will have a significant impact on users' ability to remove barriers to access that they may experience.

Key Insights from the Research

It is clear that even in the most optimal conditions, many individuals with disabilities are not receiving the assistive technology features and services they require to participate fully in society or to achieve their full potential. The research conducted through this project has shown that reaching the broadest number of users with the most optimal solutions necessitates a personalized approach to preference discovery, and one that considers a broad range of user needs, contexts, and situations. Specifically, the research suggests the need to:

- **Design for diversity.** One of the most important lessons gleaned from current practice and research is that the preference discovery environment needs to be designed to address the diverse needs and contexts of users. The language used, the user experience offered, the complexity and specificity of choices offered, whether choices are made independently or with the help of professionals or other supportive personnel must be tailored to the individual, their goal and context.

- **Avoid stereotyping or assumptions based on disability classifications.** Medical diagnostic categories or impairments are not helpful in determining user requirements or preferences as they can lead to inaccurate assumptions about a user's needs and preferences. Knowing that a user is "blind" does not address whether the user prefers Braille or speech, for example. Disability is only one characteristic that influences a user's preferences and may not be the most influential or predictable determinant. If choices must be classified, functional classifications should be used (e.g., visual preferences, audio preferences, input preferences, etc.).

- **Consider all facets of the user.** Numerous factors impact a user's needs and preferences not just factors related to disability. Contextual factors, environmental constraints, goals and motivations, role played, assistance available and other factors should all be considered in the preference discovery environment when the information is available.

- **Encourage exploration, experimentation and risk taking.** The preference environment should overcome the user's fear of breaking the system. All actions should be reversible, and the user should be made aware of the reversibility—to increase confidence in exploration. The user should also be able to completely back out of a set of preferences and go back to a previous version. In short, the user should be encouraged to play and make mistakes, and should be supported in trying out new strategies.

- **Demonstrate the chosen preference wherever possible.** Realistic simulations of specific preference choices or instant implementation of preferences assists the individual in "visualizing" the choices, understanding the implications of the choices and judging whether the choice is suits her/his individual needs.

- **Integrate usable decision support wisdom.** Data on what has worked in similar circumstances or what preferences best match a specific requirement should be judiciously communicated to the user in such a way that it is not overwhelming or prematurely biases the choices the user makes. This could also include features that enable users to communicate directly with peers, experts, and leaders.

- **Ensure that users are informed of preference decisions made on their behalf.** Any decisions or choices should be with user consent. A user may express a preference to forego notification of more minor decisions but this should be reversible.

- **Integrate into workflow.** Wherever possible preference decisions should be integrated into the workflow and context of the user experience. The user should be offered the option to make just-in-time decisions and should not be required to disrupt processes to adjust preference choices.

- **Enable continuous refinement.** The user should be enabled to continuously refine preferences settings and choices, to choose context specific or session specific preference and to choose more generic or global preferences.

- **Provide extensibility and accommodate the unexpected.** Preference discovery environments should allow users to express new preferences that may arise for them, and to discover potentially unanticipated and unexpected preferences they may have, through, for example, search functionality that offers sets of preferences mapped to users' own common language search terms.

Factors that have been identified in the literature as supporting user preference setting include social interaction and peer support, technical self-efficacy, and ease of customization, among others. Each of these factors, discussed more fully in Section 5.1 of this report, point to the fact that individual motivation to set preferences is varied and often unsupported.

In addition, this report underscores the importance of supporting preference discovery for individuals that may not yet be using computers. When a computer is being used, there is an opportunity to automatically harvest information from a user's current settings as a way to prime the preference discovery process. Getting started with these users is not a problem.

However, if a person sits down to a preference tool and a computer for the first time, and there is no information on the individual available, then the tool would not know whether the person can see, hear, or read text, or even what language could be used to communicate with the person. It thus becomes important to support individuals in these contexts through robust interface design. For example, if language preference is not known for a user, an initial screen could present the user with a field of flags representing the different countries/languages, and could accompany the flags with speech and sign language as the user moves over them with a cursor.

This research has also shed light on gaps in current technology. Key assistive technology, such as the ability to read digital math for the blind and users with attention deficit are limited to proprietary solutions that are confined to one browser on one desktop platform. Browsers currently also do not render essential digital math, such as MathML, requiring content delivery systems or browsers to render it using a plug-in or through modifications to the content delivery systems. Furthermore, many of the assistive technologies for cognitive disability are unavailable and are not flexible enough to mix and match the broad range of preferences needed. Finally, there is a need for systems to empower end users and practitioners with mechanisms for expressing demand for specific resource alternatives, given that web-based resource providers often do not supply ample basic metadata about their resources, let alone accessibility metadata.

Conclusions and Next Steps

Overall, the findings from this research suggest that AT assessment and delivery need to be effectively mainstreamed, and that disability and accessibility should be treated as relative conditions, which ensures that accommodation and accessibility processes are more resilient, up-to-date, and inclusive. The PGA project seeks to address these opportunities by drawing upon a personalized approach to digital inclusion—to increase consumer self-awareness and autonomy, to recognize the full spectrum of user needs, to acknowledge the uniqueness of each individual, to support AT professionals in delivering more comprehensive services, and to provide an approach that benefits users with and without disabilities.

Building on the research and expert feedback, the next phase of this project will entail the delivery of a prototype of a browser-based "Discovery Tool." The Discovery Tool will be a playground for exploring and discovering preferences, as a mechanism to *get users in the door* of preferences editing, and allowing them to improve their experience on the Web. The PGA software architecture needs to take into account the diversity of users, making it easier for designers and developers to create different user interfaces for different users. For example, since several of these editors are already in development within the larger Global Public Inclusive Infrastructure (GPII) effort, and one of the primary uses of the PGA project's prototype will be in conjunction with the GPII, it is important to ensure compatibility with it.

The forthcoming Deliverable 2 of the PGA work, which will present the design and prototype work, will also include a pragmatic demonstration of transformations that are possible in the near term—specifically in the OER Commons environment—as an example of a content delivery system capable of supporting preference match-making. This component of Deliverable 2 will also present an analysis of which transformations are possible today at the browser or operating system level, and which must be implemented on a content delivery system basis.

1 About this Report

This work is centered on the assumption that access to information and communication technology (ICT) is a necessity, not an option. There is widespread agreement that current approaches to providing access for digitally excluded users, including users with disabilities, are not sufficient. As such, this report seeks to inform the development of appropriate "preference setting" tools that will help individuals learn about and easily experiment with content transformations and user interface reconfigurations that may make the content or service they are accessing easier to use or to understand.

This report is the Preferences for Global Access (PGA) research deliverable for the U.S. Department of Education under contract ED-OSE-12-D-0013, for Profile Creation Support for Cloud-Based Accessibility. The report summarizes extant knowledge in the field through a scan of existing user profile systems, a review of related accessibility and education research, and the collection of expert judgment and input on how to capture and assist users in creating preference sets.

1.1 Report Outline

Section 2, below, introduces the challenges and opportunities surrounding the current state of preference assessment, and frames the PGA work within an "inclusive design" approach to accessibility—which recognizes the heterogeneity of individuals with disability. *Section 3* details the research methods and approaches used to create this report, while *Section 4* sets the stage for the report's research findings by framing the project's conceptualization of user preferences as functional requirements rather than medical conditions or diagnostic categories. *Section 5* groups the research findings into several key areas related to supporting preference customization and discovery including: ways to support access and remove barriers to entry into preference environments for individuals with disabilities, promising practices related to the discovery of preferences in web-based environments, and a description of how user and resource metadata supports customization. *Section 6* provides practical guidance for applying the research findings through eight guiding principles for addressing the needs of diverse users, and translates these principles into concrete next steps for a PGA working prototype. Finally, *Section 7* provides the conclusions to the report, and offers a view of key work accomplished through the project to date, as well as directions for further development of the work.

The report also provides two Appendices. *Appendix A* details the PGA architecture along with a discussion of key areas of consideration: security, components, user interface options, management of client-server communication, preferences frameworks, possible delivery approaches, and basic system requirements. *Appendix* B discusses the use of metadata to match preference sets to interfaces, content, and tools.

2 Introduction

This work stems from the recognition that access to ICT is not an option but rather a necessity. More and more of our daily activities are mediated in some way by digital technology: point-of-sale devices, self-service kiosks, Internet-based services, interpersonal communication, appointment booking, DVRs, etc. Access to these technologies is critical for full participation in commercial, cultural, recreational, educational, vocational and social activities. The urgency to address inequities in access is heightened by social forces that put large segments of the population at risk for exclusion: the incidence of disability, especially age-related disability, within the U.S. population (and in all western cultures) is expected to increase as the swell in population created by the baby boomers (those currently aged 48-68) moves towards old age.

This portion of the population may not be digital natives but assuredly are digital immigrants and have expectations for access to digitally mediated resources and services (e.g. mobile applications, self-serve kiosks, government web sites, home technologies, etc.) throughout their home, work and social lives. This trend in demand for access will be sustained as the second population bulge from children of the boomers (born 1975-1995), many of whom are digital natives also begin to experience age-related disabilities.

2.1 Framing the Problem: Existing Assessment Tools and Solutions

Accessibility approaches for individuals requiring alternative access to ICTs vary. For sustainability and interoperability reasons, the ideal approach is an integrated approach in which the accessibility features are an integral part of the mainstream product or application. Examples of this include features such as VoiceOver in Apple products, accessibility preferences in most operating systems, and captioning or text descriptions in digital content. Accessibility is also achieved through the flexibility or transformability of user interfaces and content presentation. This access is supported by accessibility guidelines such as the World Wide Web Consortium's (W3C's) Web Content Accessibility Guidelines and web development tools that comply with the W3C's Authoring Tool Accessibility Guidelines.

Unfortunately, while there have been advances in integrated accessibility features, and while advocacy toward accessible user interfaces and content design continues, most applications and products are still designed for the mainstream or "typical" user and rely on separate, specialized assistive technologies and post-production processes to bridge the gap between the standard product or resource and the needs of individuals with disabilities. Consequently, many users with disabilities must depend on specialized assistive technology (AT) systems. As with all specialized and separate products, the relative cost is high, interoperability with ICT hardware and software is uncertain and brittle, and access to mainstream features is incomplete and undependable.

Much of the existing knowledge base regarding the access needs of individuals with disabilities was developed through the assistive technology development and prescription process, and by the professionals, engineers, and clinicians who have attempted to address the accessibility needs of users with disabilities. This community of practice has developed a wide range of instruments, checklists, guidelines, tools, case studies and documented best practices regarding the assessment of the needs of individuals with disabilities and prescription of assistive technologies to users with disabilities. However, given the predominant context of these processes, most assessments focused on determining and documenting an individual's capabilities and deviations from the average, or "normal" individual. Also, the majority of these instruments fail to assess how resources or user interfaces should be designed to match the *individual* user's current needs, resulting in poor matching of tools and users (Fiske et al., 2009).

Individuals and families report that the prescribed accommodation resulting from these instruments may be based more on the diagnostic classification than on their personal situation and requirements (Ibid, 2009). Work by the Assistive Technology Outcomes Measurement System (ATOMS) [http://www.r2d2.uwm.edu/atoms/] provides an overview of the state of assistive technology outcomes efforts and tools, finding that most of the 50 tools evaluated as part of their review were inadequate as AT outcomes measures, and that existing rehabilitation and health functional assessment instruments do not adequately include AT devices and services as a primary or moderating variable.

Many individuals with disabilities do not have access to AT assessment services due to location or other factors such as cost. Even when these services are available and users are prescribed assistive technologies, there are numerous shortcomings as identified in the AT research literature:

1. ATs are not updated as regularly as other software, leaving users with outdated and unsupported technology options;
2. the prescribed AT system often matches a diagnostic classification rather than an individual's actual needs and requirements;
3. instead of spending their time with AT specialists learning how to use or configuring settings to use ATs independently, this time is used to prescribe systems and users acquire systems that they do not understand or cannot use independently;
4. AT systems are usually expensive and out of reach for many low-income individuals;
5. most AT systems are available in only one context such as home or work but users encounter technology in every facet of daily life and are without AT; and
6. this system of accommodation ignores segments of the population who are not disabled but could benefit from alternative access due to contextual factors (such as a noisy environment or broken headphones or temporary disability such as a sprained wrist).

The literature further reveals that as a result of the above shortcomings, many users express dissatisfaction with their AT systems (Mann, Hurren, Tomita, 1993; Hastings Kraskowsky &

Finlayson, 2001; Fisk et al., 2009, Lenker et al., 2013). Further, many users report underutilizing or abandoning their systems altogether (Reimer-Weiss & Wacker, 2000; Scherer et al., 2005). Users who cannot afford an AT system or have poor access to resources must do without or rely on the help of others (Copley & Ziviani, 2004). Finally the benefits of inclusive design (think of curb-cuts, automatic doors, captions) that may be experienced by the whole population are not realized. Global access must be achieved through other means; users move through a technology-filled world—the solutions for access need to be as mobile and context-independent as the people who use them and as ubiquitous as the technologies they seek to access.

2.2 Access Through Personalization

An important way to deliver access to these ICT services is to provide a mechanism for users of the service to modify it so that they may interact with the service through an interface and input method that matches their individual needs and preferences. One approach to providing access has been to create a few interface subsets for specific disabilities: If users are blind then pictures are replaced with text, and if they use alternative controllers (no mouse), keyboard navigation is active. This “medical model” approach fails to recognize the heterogeneity of individuals with disability and fails to recognize that access issues arise for multiple reasons: context, technology failure, access device, temporary injury and permanent disability. Accessibility that solves for “problem users” is not inclusive and only provides good solutions for individuals who are the stereotypical “problem users.”

Inclusive design places the “problem” within the design; an interface that a user cannot access indicates a failure of the design to match the needs and preferences of the user not a problem that is central to the user, such as disability. The approach to access is through personalized or “one-size-fits-one” accessibility, acknowledging the diversity of users and the full set of factors that may influence accessibility and matching the design to the individual needs of the user. Initiatives that support inclusive design (e.g., the Global Public Inclusive Infrastructure, Fluid Learning Object Exchange, Cloud4All and others) enable users with sensory or physical limitations, cognitive constraints, unique learning affordances, or other barriers to discover and articulate their needs and preferences for specific contexts, and the system automatically configures the provision of information and applications to meet these individual needs and preferences.

This project has built a deep understanding of knowledge in the field through a variety of methods described in the Research Approach section below. This information has been utilized to explore the development of tools that will help individuals learn about and easily experiment with content transformations and user interface reconfigurations that may make the content or service they are accessing easier to use or to understand. Through discovery, users will be able to apply cloud-based solutions that improve accessibility to the desired information or service.

2.3 Discovering Solutions for Functional Needs

This report draws on an inclusive design framework, where access is thought of in terms of function rather than in terms of a clinical diagnosis. Thus, instead of a user having to self-identify as having, for example, a diagnosis of blindness, and subsequently having all images in the interface automatically removed and replaced with text, a user may *choose* functional options such as having short text alternatives to images, or text alternatives with images, or long descriptions with images. These functional choices allow for the fact that individuals who are “blind” have varying degrees of visual acuity and have different ways of accessing an interface (e.g., a standard display, a braille display, magnification and/or a screen reader). This functional approach also allows users who do not identify as having a disability, but who are constrained in their ability to see, to choose access options that benefit them. It is important to note that these constraints may not be related to conventional notions of disability: device limitations (e.g. small screen), data limitations (e.g. slow connection), or acquired/temporary physical impairment (forgotten prescription eyeglasses).

A key problem to solve in the area of preference setting is guiding the user who is unfamiliar with the concept of or possibilities of personalization or individual customization of services, resources and user interfaces. When preference discovery takes place through an online system or application there is also the dilemma of designing the user interface to meet the needs of the individual who has not yet specified what they need with respect to accessibility. Helping the user learn about preference setting in a comfortable and simple way is an important aspect of the research in this report as well as in the future design deliverables. It is important to consider how users who do not feel at ease with technology and do not have the benefit of a tech-savvy helper will be able to engage in a preference setting dialogue. Development of a mechanism to bring preference discovery and selection to the user in an unobtrusive but helpful way is an important problem to solve. The Discovery Tool discussed in Section 6 of this report provides a potential solution. Enabling users to explore preferences and to learn how to overcome barriers to access and improve their experience with technology will have a significant impact on digital inclusion, and on the range of essential activities and services mediated through digital systems.

2.4 Motivating Examples

This report centers on three key concepts:

1. That technology mediated information and services are accessed for diverse goals, in diverse contexts and by diverse users with hugely diverse access needs.
2. That we will empower individuals if we provide tools that help them discover and learn about and request individualized resources, services, and interface configurations.
3. That the goals of the Preferences for Global Access work benefit all users and not just people with disabilities.

For example:

- Sam prefers to use speech input whenever possible, and when her neck is tired from looking up at her laptop monitor she uses speech output to listen to long text passages instead of reading from the screen.
- Kyle prefers to learn in American Sign Language. If he has to use English, he prefers a Grade 5 reading level. Video and audio materials should have either captions or an ASL transcription.
- Lois can use a touch screen with low accuracy. She needs buttons at least 2 cm wide, font sizes at least 32 pt, and software filters that ignore screen touches other than taps longer than 1s. She is not aware of these specifics—her occupational therapist has set up her tablet, and the applications she uses.
- Oliver is a visual learner and prefers graphical representations of information, and text to be read out to him. He uses a dictionary and thesaurus frequently. Visually cluttered views are distracting.

The examples above illustrate just a fraction of the breadth and complexity of the needs and preferences that help individuals to use technology effectively for learning and other activities. Some of these preferences are permanent and essential. Others are transient, or "nice-to-have". Some can be clearly expressed ("provide a dictionary") while others may not be known to the individual ("graphical representations are better"), or may not be easy to express accurately ("make the touch screen less sensitive"). Some are device-specific while others are more general. Some preferences have associated information that is needed to provide a consistent experience in different contexts, such as the voice model for speech recognition.

The goal of this report is to summarize research and to inform evidence-based ways to discover an individual's preferences, for all of the above situations and more.

3 Research Approach

As outlined below, the information in this report was developed through a series of research phases that included a literature review and the compilation of examples of preference approaches, sets and mechanisms. Subject matter experts (SMEs), as part of the PGA project team, utilized the findings of this research to extend and support their understanding and experience in the field and together began to articulate problems of access and barriers to entry as well as debate and develop the most effective ways to approach defining and presenting preference specifications. The conclusions of these discussions form the jumping off point for possible design solutions that may be prototyped and tested.

3.1 Review of User Profile Systems and Accessibility Initiatives

A review of existing user profile systems and accessibility initiatives was conducted to capture and assess insights from the field around supporting individuals in discovering their preferences. This component of the work began with a collaborative brainstorm session to create an initial list of initiatives and platforms to scan, with an eye toward those that support the collection of user preferences (both disability and non-disability facing) or the matching of user preferences to web-based resources, as well as an eye toward those that support accessibility through the development of standards and data protocols. A set of criteria was created to guide the review process that included the central questions that the project sought to answer:

- **Intended purpose**. How does the initiative support accessibility, if at all?
- **Disability-facing**. Is the initiative meant to explicitly support disabilities, or is it intended for other needs not tied to the disability community?
- **Target audience**. Who is the key audience the initiative is trying to serve?
- **Preferences covered**. What user preferences does the initiative cover, if any? How are preferences named and grouped?
- **Getting people in the door**. What can we learn from the initiative with regard to the mechanisms that facilitate access and remove barriers to entry for individuals with disabilities as well as users more generally?
- **Flexibility**. What can we learn from the initiative in terms of how to best accommodate new preferences that arise for users? Can preferences be set to vary by environment?
- **Data collection and preference assessment**. How does the initiative lend to our understanding of how user preferences are assessed, and of the ways that existing preference data can be leveraged across platforms, tools, and initiatives?
- **Flow and sequence**. What insights can we glean related to how platforms or tools can best order their requests for information from users to assess their preferences?
- **Opportunities for leveraging their work**. Overall, how does the initiative inform our work? What are the broader lessons learned?

Once the review criteria were established, a spreadsheet in Google docs (Global Preferences Platform Scan) was created and shared with the project's subject matter experts (SMEs). The SMEs were prompted to add names of, and enter information on, additional platforms and initiatives. We then conducted an initial review of the 61 platforms and initiatives that resulted from this process, and narrowed in on 27 that surfaced as most relevant to our project efforts based on their ability to answer the questions within the review criteria listed above.

Table 1, below, lists the 27 platforms and initiatives reviewed in depth, grouped into categories of: a) preference management, discovery, or collection tools; b) initiatives that support the creation of accessibility standards and specifications; and c) "other", which includes learning platforms, learning discovery tools, and content matching systems. Although several of the projects span more than one category in the table below, they are grouped according to the central way that they supported knowledge building in the PGA work. Key findings from the analysis of the 27 platforms and initiatives are integrated into the narrative of this report, where relevant.

Table 1: List of platforms and initiatives reviewed in depth

Preference management, preference discovery or preference collection	**Accessibility standards, specifications, and data protocols**	**Other** (learning platforms, learning discovery tools, and content matching systems)
• Mada Center Self-Assessment Tool • Cloud4All • OTFACT • Web4All • The Inclusive Learning Exchange • Microsoft Windows Ease of Access Center • National Strategy for Trusted Identities in Cyberspace (NSTIC) • Lumosity • StumbleUpon • Global Public Inclusive Infrastructure (GPII) • Global Accessibility Reporting Initiative • Facebook	• Accessible Portable Item Protocol (APIP) • Dynamic Learning Maps Project • IMS Access for All • ISO 24751 • Web Accessibility Initiative (W3C WAI) • IndieUI • Learning Resource Metadata Initiative (LRMI) • Schema.org	• Carnegie Mellon Cognitive Tutor • Keyboard Optimizer • SUPPLE • OER Commons • Sophia • Teachers' Domain • Flexible Learning for Open Education (FLOE)

3.2 Review of Literature

In addition to the scan of existing profile systems, a review of literature was conducted to capture extant theory and empirical work in the user preferences space. The initial approach to the literature review was to create a shared spreadsheet (Global Preferences Literature Review) as a template for the subject matter experts and other project partners to enter names of articles that they deemed as relevant, and to add high-level summaries and key takeaways from those articles. By scanning the insights from this early compilation of articles and reports, a list of key topic areas of relevance to the project was created, ranging from issues around how to support entrance into preferences environments, to discovering and assessing preferences, to organizing and presenting preferences, to matching preference sets to content, to system architecture and design. Additional literature was subsequently reviewed within these topic areas. As the work progressed, we were able to identify gap areas and narrow in on additional topics that needed further exploration within the literature, including work in the realm of cognitive needs, differentiated learning, and learning resource metadata, among others. Insights from the review of literature are presented in relevant sections of the findings, below; a full reference list is included at the end of this report.

3.3 Collection of Expert Feedback

The research has also entailed the collection of feedback from participating subject matter experts (SMEs). The SMEs have contributed to the research deliverables through: a) actively participating in the project listserv by sharing ideas on new innovations and related initiatives in the space, as well as raising and providing input on key issues that have emerged through the work; b) adding, reviewing, and summarizing articles and reports for the literature review; c) adding, reviewing and summarizing preference platforms and tools for the platform scan; d) taking ownership for the construction and writing of specific sections of the research report at hand; and e) providing feedback on the research report as the sections were written. Mechanisms were also instilled to solicit feedback and input from other field experts, outside the project group.

Preferences for Global Access (PGA) team members have presented at several venues since the commencement of the project. For example, at CSUN and SXSWEdu, the members of the PGA team designed presentations to solicit user feedback on the existing preference systems and identified needs for preference systems. Megan Simmons (ISKME) and Colin Clark (OCAD) presented on "Portable Profiles for High Access Learning" at South by Southwest Education, SME team members Jim Tobias (Inclusive Technologies), Rich Schwerdtfeger (IBM) and Madeleine Rothberg (NCAM) presented on the project at 28th Annual International Technology and Persons with Disabilities Conference (CSUN), and Jutta Treviranus and Lisa McLaughlin presented the project and engaged educators at Big Ideas Fest 2012. Expert feedback has also been solicited through invitations to external stakeholders to join and contribute to the project listserv, including Internet2. We have also encouraged and implemented cross-posting to both the project listserv and the Cloud4All and Fluid work lists as a mechanism to solicit feedback and input from affiliated communities. All listserv members have access to a shared Google folder where collaborative working documents are stored, as well as project management documents such as work plans and timelines.

4 Framing Preferences

In line with AccessForAll, an accessibility standard and a design philosophy, the point of departure for this project is the recognition that a) people with disabilities are one of the most heterogeneous groups, one that does not fit neatly into diagnostic categories, and b) that diagnostic categories are often misleading and may only be a small factor in an individual's needs and preferences (Neville et al., 2005; Neville & Treviranus, 2006). As such, both disability and accessibility are seen as relative conditions or traits, and disability in a digital context is viewed as the result of a mismatch between the needs of the individual and the resource, service, or environment provided (Ofiesh et al., 2002; Treviranus & Roberts, 2007).

Following this reasoning, the Preferences for Global Access (PGA) project seeks to address the preferences of all users whose needs or requirements are not met by the current system design, including disabled users as well as those not formally classified as disabled, but who face barriers to access to content, tools and services due to a mismatch between their needs and the content, tools or services offered.

4.1 Preferences as Functional Descriptions

This project frames user preferences in terms of functional descriptions of how users prefer to have information presented, how they wish to control any function in the technology application, and what supplementary or alternative content they wish to have available. Initial AccessForAll specifications and standards (Neville and Treviranus, 2006) delineated three main classes of such preferences, or requirements:

- **Display requirements***,* which include the use of screen readers or enhancers, tiny phone displays, reading highlights, Braille, math readers and navigators, tactile displays, visual alerts and structural presentation.
- **Control requirements,** which include the use of specific control devices (keyboard, trackball, touch-screen, switch), software alternatives/supplements to control devices (onscreen keyboards, switch software, speech recognition, mouse emulation), and software modifications to control signals generated by devices (Sticky Keys, key repeat behavior, double click timing, tremor suppression).
- **Content requirements,** which include the use of alternatives or supplements to each of the modes of display (auditory, visual, tactile, textual), as well as learning aids to support cognitive needs.

The International Standards Organization (ISO) 24751 initiative is developing a standard and interoperable ways of describing preferences and digital resources, as well as a framework for matching individual preferences with the optimal resources. ISO 24751 is used in Flexible Learning for Open Education (FLOE), Cloud4All, Prosperity4All and other projects, as well as Global Public Inclusive Infrastructure (GPII) itself. This initiative and the projects implementing the standard, have added a variety of additional preference categories to accommodate the expanding diversity of user needs. Among these are preferences regarding privacy and security which are particularly a priority for senior citizens, language preferences, preferences related to workflow, and an expanding set of other preference categories.

4.2 Preferences Matrix

Drawing on emergent functional categories within the field, the PGA team reviewed literature in the domains of education, special education, and information science, and collected knowledge from within the project's own subject matter experts, as input into the creation of a preferences matrix. The preferences matrix comprises an extended list of disabilities and needs that moves beyond extant work in the accessibility and special education literature, to include cognitive needs, contextual needs, and individual learning styles and preferences. Table 2, below, lists and groups some of the disabilities and needs that arose through our work on the preferences matrix, and provides examples of their functional equivalents, or preferences (note that preferences often fall into more than one category of disability/need).

In compiling the preferences matrix, our work revealed that although cognitive needs potentially impact the widest number of users, accessibility standards and solutions have not done an adequate job of addressing this group of users. This is due to several factors, including the complexity and wide variation in the realm of cognitive needs, that solutions vary based on user context, that there is a lack of developer education on the needs of cognitively impaired users, and that there is a lack of a single vehicle for capturing cognitive needs. Hudson et al. (2004) discuss ways that web content can be more accessible for individuals with cognitive disabilities, including the use of inverted pyramid writing, summarizing content, the use of expanding bullets, and the option to select long and short information. Work by Lewis et al. (2012) as well as others has revealed the importance of MathML to students' perceptions about their math abilities and to improved outcomes in math. In expanding on this literature and drawing on the expert knowledge of individuals working in the cognitive space, we have developed an extensive list of cognitive needs and associated preferences, as reflected in Table 2, below.

Furthermore, our work has shed light on the need for exploration into how contextual or environmental factors impact or relate to needs and preferences. Hurst et al. (2008) explored variation in pointing performance on the desktops of individuals with cerebral palsy, and conclude that variation in performance at different sittings is so high that it calls into question the value of basing personalization on the results of a single session of user customization/personalization. In light of research such as this, the PGA team began to develop an initial list, also reflected in Table 2 below, of context-related preferences, including environment (library, home, office, etc.), device used (phone, laptop, etc.), structure of the expected learning activity (individual or group), and presence or absence of a practitioner, teacher or caretaker.

Table 2: Examples of user needs mapped to preferences

Examples of Constraints and Needs	Examples of Preferences
Physical/Sensory	
Vision	Larger fonts, easier to read fonts, white spacing (character kerning, interword, interline), line length, enlarged cursor, highlight text, improved contrast including color reversal, use of headings, text boxes, borders, sidebars, and other formatting tools, removal of extraneous text and other content such as ads, audio description, and screen reading
Hearing	Visual alerts, captions, frequency modulation and equalization, reduction of background noise (by audio engineering and removal of music and effects tracks), sign language interpreting
Fine motor skills, dexterity and strength	Track ball, keyboard and mouse input modification utilities (e.g., StickyKeys), head tracking, eye gaze tracking, onscreen keyboard, alternative input systems including scanning, coded input, 2D and 3D gesture recognition, speech recognition
Chronic fatigue	Print enlargement, increased font size, save, pause and resume task
Cognitive	
Attention/concentration (also covers inhibition control)	Disable background audio; disable ads, disable blinking text, restrictive views, highlighting and speaking math & text under user control, recoverable history, reminders or “nags”, breadcrumbs, timers, tachistoscope; summarization of key points; repeated exposure to tasks
Memory	Voice to text note taking, video with concept, calendar, timers/alerts/alarms, breadcrumbs, activity/achievement logs, wizard, reminders or nags
Linguistic comprehension	Simplified text and structure; consistent use of terms, glossary/dictionary/thesaurus; translation into another language
Math comprehension	Speak text and symbols, explain mathematical concept
Reading comprehension	Speak text, simple sentence structure, show graphic image or video/animation, a view bar for isolating text while reading, foreground and background color manipulation, font size increase
Visual comprehension	Supplementary images, adjustable color scheme, text and audio alternatives
Problem solving	Goal tracking, bread crumbing, teamwork, ‘lifeline’ to team or teacher/expert
Self monitoring	Goal tracking, calendar, log of activity and completion
Emotional regulation	Practitioner help or social interaction, alerts that refocus users to different problems or content, positive feedback
Planning	Goal tracking, calendar, breadcrumb, wizard, step tracking (e.g., ‘you are on step 5 of 7’)
Contextual/Situational	
Device or application used	Access to settings on the chosen device or the application, and ways to supplement them
Environment (location, setting, lighting, etc.)	Video and audio subtitles for noisy or silent environments, high contrast color schemes and brightness for low light; increased legibility (including font size) when in motion (bumpy ride)
Presence of caretaker, peer, or expert	Settings related to user customization vs. caretaker customization, vs. system customization
Mood/emotional state	Mood log, mood mirror

Examples of Constraints and Needs	Examples of Preferences
Learning Specific	
Learning scaffolds	Annotation tool, thesaurus, dictionary, social learning tools (shared notes, comments, team-based projects)
Learning context	Options to select varied types and forms of content, content flexibility, access to supplemental content; Ability to re-schedule or move items up or down a to-do list based on, for example, the urgency of the learning task; social vs. solitary; connection to previous evaluations or requests for support ('you're seeing this content via another medium because you said you were confused about this topic last time')
Learning pace	Mechanisms to pause, stop and start and record, repetition mechanism; settings relating to how much time the user has or wants to spend and how much control they can usefully exert, deadlines and timers.
Motivation	Gamification and rewards (e.g., badges and other recognitions of achievement); Competition and teamwork

This work clearly illustrates the need for an approach to preference discovery that involves multiple means for representation and engagement on behalf of users. In the case of users with math comprehension difficulties, for example, text highlighting and speech synthesizers are used to provide an enhanced math experience. The user can also be engaged by controlling the pace with which they navigate expressions, set place markers, and obtain content overviews. This same strategy can be used for users who are blind, with the exception that he or she will want the beginning and ending of each expression to be stated in addition to the verbalized expression. However, for example, a learner with attention deficit would likely consider this additional information overload or "noise." On the whole, the preference matrix work both surfaces and underscores the need for an ontology that can support traditional as well as functional needs of users, and that recognizes that new contexts are facilitating the development of new preferences continuously, and that these need ongoing research to support their inclusion.

5 Key Findings: The Preferences Environment

This section groups the research findings into several key areas related to supporting preference customization and discovery including: ways to support access and remove barriers to entry into preference environments for individuals with disabilities, promising practices related to the discovery of preferences in web-based environments, and a description of how user and resource metadata supports customization.

5.1 User Customization

When provided with the option, some users will customize their interface while others do not. Understanding how to support preference setting and how to ensure that all users are able to access and set preferences is discussed below.

5.1.1 Do users bother to customize their ICT tools?

In order to understand how needs and preference collection tools should work, it is important to first understand the larger issue of how users approach (or even avoid) the domain of customization, and the factors that have been shown to support higher rates of user customization. While some researchers have found high levels of customization, especially among frequent or experienced users (Page et al., 1997; Sundar & Marathe, 2010), several studies point to low levels of end user customization of applications (Iyengar et al., 2000; Forrester, 2004; Spool, 2011).

Spool (2011) points to the consistent finding across his research on customization that users rarely change their settings. Other studies have shown that in some cases, low customization rates reflect larger decision-making behaviors, in which users display biases towards the status quo, inaction, and decision avoidance (Samuelson & Zeckhauser, 1988; Ritov & Baron, 1992; Tykocinski et al., 1995; Dhar, 1996). These cases are usually with users who are able to manage or “make do” with the default settings; many users cannot and are effectively excluded when preference setting is difficult. Trewin (2000) discusses barriers to customization for less experienced users in particular, including lack of confidence in configuring applications, lack of knowledge on how to change settings, lack of awareness of available options, difficulty identifying the solution to meet a given preference or need, and a lack of control over the unconfigured interface.

5.1.2 Factors that support user customization

On the whole, the literature indicates that power users prefer user-driven customization, while non-power users prefer system-driven customization (Sundar & Marathe, 2010). This raises the larger issue of user preference for customization driven by the system creating defaults or making recommendations (adaptive), versus customization driven by the user’s exploration and decision-making (adaptable) (Findlater & McGrenere, 2004; Trewin et al., 2004; McGrenere et al., 2007). Each design approach, including a hybrid approach, has factors that may be advantageous for some users, while deterring other users (Trewin et al., 2002; Gajos, 2004). Another approach allows a practitioner to pre-select certain interface settings, after which the user would be encouraged to adjust the settings using an adaptive, adaptable, or hybrid system. It is not clear from the research, however, if making user customization easier to understand and use actually increases user-driven personalization.

The following sections contain specific factors that researchers have attributed to higher customization rates.

5.1.2.1 Social interaction and peer support

Several authors discuss customization as a social activity, and point to key factors to support customization, specifically related to sharing with and leveraging peers. These factors include:

- Ability of users to view configuration files shared by other users or observe other users' customization. Banovic et al. (2012) and Rogers (2003) found that users informed of a friend's customization performed more customizations themselves. Mackay (1991) found that new users are more open to customization, but may know too little to make effective decisions.
- Access to an individual, or helper, who can provide support and assist with management of options and preferences (Forrest et al., 2008). This can include practitioners, as well as others in the user's effective social circle. Research has shown that this is especially true for older users, who may be in search of personal interaction, and may be more comfortable with personal assistance than they are with figuring things out on their own (Simon & Usunier, 2007; Lee et al., 2010).

Within the field there exists several mature and active peer support networks, such as Blind Planet [http://www.blind-planet.com], and the many local "wheelchair user groups." Most of the popular social networks (Facebook, LinkedIn, Google Groups and Twitter) have assistive technology user groups. Some are more active than others, and discussions tend to be sporadic and inconsistent. Most suffer from a lack of filtering or organization of posts and discussion themes.

In the larger consumer technology environment there are a number of initiatives that seek to equalize the dynamics in the relationship between consumers and producers of technologies by raising consumer awareness and fostering active consumer participation in technology design. There are a number of nascent initiatives in the AT consumer domain that follow this model. One example is the A11y Camp initiative, a global effort to engage persons with disabilities and their community in actively addressing accessibility issues [http://www.a11ycamp.org]. Disability-specific examples include the "Blind Geek Zone" [http://www.blind-geek-zone.net]. While these peer efforts can provide valuable anecdotal insights and advice regarding assistive technology features that address specific requirements, and can in turn support user customization and preference setting, the information is fragmented, sporadic and not organized in such a way that it acts as an effective decision-support tool. However, the peer efforts are valuable resources for collecting user requirements and incubating innovative ideas for addressing these requirements.

5.1.2.2 Technical self-efficacy

Spool (2011) and others (Marathe & Sundar, 2011; Banovic et al., 2012) have shown that more experienced users, and high frequency "power users", customize more than less experienced users and low frequency users (Page et al., 1997). Awareness continues to be a barrier. For example, in recent interviews of 16 smartphone and tablet users with developmental disabilities, none seemed aware of the accessibility settings when asked how they would change their device to make it easier to use, despite being interested in the available settings when they were described (Trewin, submitted for publication). Others have found that power users prefer user-driven customization, while non-power users prefer system-driven personalization (Sundar & Marathe, 2010). Other factors related to users' technical self-efficacy found to impact customization rates include:

- Confidence in configuring settings, and a sense of control over the unconfigured interface (Trewin, 2000; Forrester, 2004; Weintraub, 2006).
- Trialability, or the users' confidence in undoing and redoing customization (Rogers, 2003; McGrenere et al., 2007).
- Previous successful customization (Mackay, 1991).
- Intrinsic personal innovativeness, in terms of being more likely to try new things as early adopters (Rogers, 2003).
- Explicit exposure to the tool and its operation, through for example, training opportunities. Banovic et al. (2012) found that those exposed to a customization tool customized soonest; non-power users responded most to exposure.
- Response to software change, or the users' preference to restore previous features by customizing so that the software works as it did before the change (Mackay, 1991).

One example of how existing platforms address issues of users' technical efficacy is the Keyboard Optimizer, which provides users with a large "undo" button, offering users the ability to try a particular customization and easily undo or redo their preferences.

5.1.2.3 Ease of customization

Factors related to the perceived complexity and overall ease of use have also been cited within the literature as impacting customization rates:

- Offering fewer configuration choices or options, to reduce, for example, the possibility of overwhelming the user (Iyengar & Lepper 2000; Reutskaja & Hogarth, 2009).
- Categorization and bundling of options to support sensemaking and a feeling of control over the unconfigured application (Mogilner et al., 2008).
- Easy access to the customization tool by the user, and ease in finding the settings or options needed (Trewin, 2000; Forrester, 2004).

- Low level of difficulty and anxiety for the user in customizing (Venkatesh et al., 2003).
- The presence of an explanatory function: Bunt et al. (2007) found that for some users who were provided with rationales about customization, especially when these were suggested by the system, the rationales were useful in establishing trust, understandability, and predictability.
- Use of interfaces that are automatically rendered and aligned to specific disabilities, and that users can interact with to further tailor to their needs and to their varied capabilities (Gajos et al., 2007).

Social media platforms such as Facebook attempt to facilitate the customization process by putting settings in the context of where they are needed. For example, privacy, timeline, and tagging settings are close to account settings, and the setting for who can "friend" a user is next to his or her friend requests. In this way, users encounter ways to change settings as they use different parts of the site. Another approach, employed by Microsoft Windows Ease of Access Center (Vista+), is to offer easy-to-activate, clearly described customization options on the starting screen of its control panel. This approach puts customization front and center to the user, and offers an explanatory function to aid the user in making customization decisions.

A third example of an initiative that simplifies the customization process is the Global Accessibility Reporting Initiative, which offers users a set of features corresponding to five disability categories. The user must be able to understand the features that he or she needs or prefers, and identify and accept one of these disability categorizations; however, each feature has an explanatory popup and all features can be seen at once. Finally, to assist users in customization, tools such as the Sophia Learning Styles Personalization Tool allows users to create a learning profile for content delivery based on a set of questions from a wizard. Through the wizard, users can identify whether they prefer auditory, visual, verbal, interpersonal, or applied learning approaches. The use of simple questions, asked from the learner perspective, and which are embedded in the user experience, allows users to make customization preferences easily and seamlessly.

5.1.2.4 Alignment to outcome and performance expectations

Factors related to users' expectations on the benefits of customization to their performance and productivity also surfaced as important within the literature:

- The perception that there will be a productivity payoff (Rogers, 2003), that there is relative advantage in using the customization tool over not using it (Venkatesh, 2003), and that customization tasks do not distract from other productive activities (Mackay, 1991).
- The perception that productivity is currently jeopardized, and that customization is necessary to repair and move beyond a breaking point or problem (Mackay 1991; Banovic et al., 2012).

- The ability to meet intrinsic and extrinsic motivations tied to users' goals, which can be met only through customization (Venkatesh, 2003).

Two existing tools that attempt to leverage users' personal goals are StumbleUpon and Lumosity. In both cases, customization occurs as part of the registration and sign-in process. With StumbleUpon, users are given a list of interests and must choose at least five interests to personalize their "stumbles." StumbleUpon then sends users pages with topics relevant to those interests, tailored to past Internet searches, and aligned to what other StumbleUpon users with similar profiles have liked. With Lumosity, users are asked to choose aspects of cognitive areas they would like to improve, and from those responses as well as their stated age, Lumosity builds a personalized training program.

5.1.2.5 Other

Several other factors that play a role in user customization rates, which do not fall into the categories above, also surfaced within the literature:

- Opportunity and environmental factors, including boredom and having enough time (Mackay, 1991).
- A sense of opting in to customization, in terms of: "It is my choice to customize, and I don't have to if I don't want to" (Moore & Benbasat, 1991).
- An external event, such as job change (Mackay, 1991; Venkatesh, 2003).

5.2 Getting Users in the Door

The research summarized above points to the necessity of meeting all users where they are. The discussion below builds on this research by highlighting three considerations related specifically to how users' and practitioners' daily activities, contexts, and existing technologies can be leveraged as a means of drawing them into preferences environments.

5.2.1 Points of tangency in daily living

As noted above, researchers have found a lack of awareness of preference options among technology users, and limited customization of those options, even for everyday applications and devices (Cox, 1996; Trewin, 1998; Spool, 2011; Anthony, 2013). Users encounter situations every day where they interact with technologies or with people who might be interested in their technological performance and their comfort. There are numerous opportunities in daily life to leverage these conversations or interactions to help users understand what is possible, and express at least some preferences.

For example, receiving a new device is an instance when users may be willing to spend time performing personalization (Kane et al., 2009). For learners, as an example, personalization can be supported by leveraging educational intersections—such as data collected as part of standardized testing, when students transfer schools, or when they enter into remedial, enrichment or supplementary programs. As an example, the Accessible Portable Item Protocol (APIP) Standard, which supports the creation of tests tailored to specific accessibility needs of students, draws on information about student needs from existing school information systems. Other, similar opportunities that can be further explored through future research include:

- Libraries or bookstores (for example, data stemming from requests for large print books or captioned videos).
- Emergency preparedness (information on how individuals want to be notified, who should be contacted if 911 is dialed, etc.).
- Home technology installations (e.g., an engineer installing a set-top box for a television could help a new user to configure the interface, and then provide a link to a more comprehensive assessment process).
- Data stemming from medical visits, which may reflect changes in functional abilities, temporary or permanent.

These points of tangency can be engineered into a preference setting opportunity for the user, which can be limited to the needs of the moment, or an onramp to a more complete evaluation. Either way, it is essential to make the experience as seamless as possible with the rest of the user's life. Many users will have had negative experiences with evaluation, or with their own explorations of technological interfaces. They may also, based on negative experiences, resist or resent clinical tools that seem to judge or oversimplify their abilities or even their identities.

5.2.2 Extensions of mainstream technology

Some mainstream technologies provide ways of adjusting the user interface through permanent settings, or point to assistive technology options external to the mainstream products themselves. For example, the Windows Ease of Access wizard lets users set operating system features, and points users to external assistive technologies for preferences beyond those features; however, there is no operational connection between the wizard and the external assistive technologies.

Preferences can also be made available through add-on modules for mainstream technologies. For example, the IBM WebAdapt2Me project was delivered as plugins for the Internet Explorer and Firefox Web browsers (Hanson et al., 2006). This approach enabled one-click access to a preference toolbar in which users could adjust preferences and immediately see the impact on their current web page. Placing the preference in the current page context allowed users to make informed preference decisions. It also made it easy to tweak preferences when the usual values did not work well for a particular page. For example, a user could turn on the 'Hide background image' option when viewing a poorly designed page with distracting images behind the text, and quickly turn it off again when they were finished with that page.

Social networks, as well as online games—in the form of, e.g., reaction tests, puzzles, memory tests, and problem-solving games—are mainstream applications that users may already be using, and their preferences can potentially be extrapolated and transcoded from these technologies. From the platform scan, Lumosity surfaced as one example of a technology that can be leveraged for a preferences environment. Lumosity is an online brain training program consisting of nearly 40 games in the areas of memory, attention, flexibility, speed of processing and problem solving. Lumosity builds a personalized training program based on how users answer questions related to what they would like to improve (such as improving productivity at work, maintaining focus, etc.).

Furthermore, the research community has begun to explore the potential of unobtrusive performance monitoring to identify access barriers, with some success. The Dynamic Keyboard (Trewin, 2004) is a utility program that monitors typing patterns and identifies and implements appropriate keyboard accessibility settings. With this approach, users whose needs vary can have their settings automatically updated. Hurst et al. (2008) monitored mouse usage in order to understand in situ pointing problems for users. Their work identified high levels of day-to-day variance in pointing ability, suggesting that ongoing monitoring and adjustment may be beneficial in other areas of input.

5.2.3 Extensions of clinical practice

In many cases in learning environments, assistive technology and accessibility practitioners are engaged in evaluating users and assisting them in finding and using short-term accommodations. At the same time they are assisting users in building long-term self-assessment, advocacy, and solution-finding skills. Some of these professionals are likely to adopt a cloud-based accessibility preferences approach. However, many others may find it difficult to adopt an externally-created tool that may be too different from the evaluation protocols and tests they use in their practice.

Prior research (discussed above) revealing how technical self-efficacy and ease of use play a role in user customization (Mackay, 1991; Trewin, 2000; Forrester 2004; Weintraub, 2006), points to the importance of adapting the preferences environment to practitioners' current tools and practices. These vary widely by domain; audiologists have very different tests, tools, and professional norms than special educators or occupational therapists, so preference tools may have to be dimensionally flexible.

Trewin et al. (2002) revealed how it is possible to incorporate new tools into technology assessment processes. The Keyboard Optimizer—a 'configuration by demonstration' tool for keyboard accessibility settings—was tested in professional assessment sessions as a way to help practitioners and individuals quickly arrive at a reasonable initial configuration by having users demonstrate how they type, and offering adjustments. The research showed that users liked having the specific settings chosen for them automatically. This is in line with prior research revealing how some users, especially older users, prefer or benefit from personal interaction related to customization of their settings (Simon & Usunier, 2007; Lee et al., 2010), or from leaders who can provide support and assist with management of options and preferences (Forrest et al., 2008). Today, occupational speech therapists are making increased use of tablet devices in sessions, providing an opportunity to gather information and use it to guide suggestions for adaptations.

Several scholars in the education field have also explored whether learners, in particular, are benefiting from practitioner assessment and decision making on accommodations. For example, Fuchs and Fuchs (2001) showed how teachers lack data about learner needs, resulting in choices that do not improve student performance. Higgins et al. (2012) further found that due to lack of training in selecting test accommodations, teachers selected too many accommodations for their students.

A disparity between practitioner training on assistive technologies and their job requirements has also been noted in the literature (Smith & Kelley, 2007; Judge & Simms 2009). Furthermore, training does not necessarily carry over to the accessibility features and settings in mainstream technologies. That is, a practitioner who has had some training on assistive technology products may not be confident in selecting technology or helping users adjust their mainstream software (e.g., Marsters, 2011; Zhou et al., 2012). This suggests the need to shift from a prescriptive model of practitioner service to a more contingent, perpetually adjusting one. We cannot assume that assistive technology practitioners can "prescribe" mainstream interface features, nor can we assume that most users can perform all customization for themselves. The answer in many cases will be a flexible, contextually-aware process that allows for and even encourages ongoing exploration of preferences over time.

5.3 Initial Entrance into a Preference Environment—A Unique Problem

Although essentially absent from discussions within the accessibility literature, it is important to highlight that one of the most challenging stages in the preference environment is the initial entrance screens. This is a particularly difficult problem if evaluating someone who is not already using a computer. If the individual is using a computer, one would be able to harvest information by looking at the assistive technologies and the settings they are currently using. Getting started with these users is not a problem.

However, if a person sits down to a preference discovery tool and a computer for the first time, and there is no other information available, then the tool would not know whether the person can see, hear, or read text, or even what language could be used to communicate with the person. Before the evaluation of a user's needs and preferences can commence, a means to communicate needs to be established that the individual is able to understand. This can be addressed through parallel presentation on the first screen (e.g., presenting some basic questions in text, speech and sign language and asking initial questions about the best way to communicate and present information). However, language must be determined first, in order for this strategy to work.

5.3.1 Language determination

The most difficult aspect of initiating the discovery process is language. The traditional strategy for language selection of providing a screen full of flags will not work if the individual cannot see, and presenting languages orally can take some time and is problematic if the person does not understand that language selection constitutes the task at hand (as no instruction can be provided if the individual's native language and sensory abilities are not known). For this reason, if nothing else is done while setting up the evaluation tool for use by a person, having someone indicate the language that should be used to communicate with the user (or at least *a* language that the communication can begin in, that will be understood by the user) is highly desirable.

Some methods for discovering a language that the person can understand must be provided, that makes no assumption about the user's communication modality (print, speech, sign, etc.). One attempt might be to have the initial screen present the user with a field of flags representing the different countries/languages, and to accompany the flags with speech and sign language as the user moves over them with the cursor. The most probable languages for that region might be presented vertically at the top of the page with the corresponding language spelled out in that language. After this initial listing of most probable flags, the rest of the flags might be presented in rows across the page.

However, people who have not used a computer before may have no idea of the function of a cursor—and no instructions can be given to tell them to press the arrow keys. Visual cues to press the arrow keys only work for those that can see. If the individual cannot use a keyboard, touching the screen will not work because the screen will likely not be large enough to display all of the needed flags, and scrolling may not be known to them.

Even the use of flags can be problematic. Some countries have one flag, but many languages. In some regions it may not be possible to easily discover the language without some foreknowledge of the region that the individual comes from and the likely language that he or she understands. Also note that some countries may use a similar spoken language but different sign language (e.g. the U.S. and England).

The importance of knowing at least the language or perhaps even a communication mode that will work (or some idea that can limit the number of languages to be tried)—and to demonstrate basic interaction with the computer—may be required. Once a language is determined, the tool can then proceed to determine which language or dialect the individual prefers rather than just one that they can understand. But before it can do that—it has to identify a physical means that the person can use to respond. Without this, nothing can be learned from the user.

5.3.2 Physical response mode

Once the language is established, the next step must be to identify an effective mode for the user to respond with. Again, initially it is only necessary to find *a means,* not the best means. Once a means is identified, it can be used to determine better means.

For most users, an assumption that the individual can use the arrow keys and return key on the keyboard is made. While this may be true for most individuals it will not be true for all. And for those that cannot, the discovery cannot continue without determining and establishing at least some other mode. As a result, part of the initial steps of entrance process will also have to include discovering a way for the individual to be able to physically respond to the discovery tool. Ideally, at a minimum, they would have the ability to signal up, down, select, and back for better reliability and efficiency. However, single switch scanning is possible as an input method. This might involve using the keyboard as the single switch, or it might require connection of a special switch (sip-puff, eyebrow, or headrest mounted for examples). It should also be possible for them to use some other communication aid as an "alternate keyboard". Touchscreens can also be used, and while cognitively simpler, they require motor control, reach and endurance. Again, if an assistant is available, having the assistant specify how the individual would provide these input signals can be much more straightforward than trying to discover them automatically, but this should be a shortcut not a requirement.

5.3.3 Communication/response reliability

Throughout the process above, all communication is done in very large print, speech, and sign language. The next stage is to try to ensure that good communication is established. By asking a series of questions the reliability of the person's responses in their understanding of the arrow keys and enter key are established.

5.3.4 Communication modality

Once it is established that the user understands and can reliably use the arrow keys and enter key to navigate and respond (or some other method of response if this will not work), the modality of communication must then be established. Does the person communicate best using text, sign, or speech? If the individual cannot communicate through one of these (e.g., they need to use a special symbol set), then a more specialized evaluation will need to be carried out. Some users may wish to communicate in multiple formats (large print and speech for example).

5.3.5 Preferred settings for communication modality

Next, the size of print and the rate of speech that the person prefers need to be identified. At the same time, the limits of font size (e.g., what is the smallest print that they can reliably read) and their preferred speech rate for maximum understanding are determined. These are important because the evaluation can be much more efficient if it can be conducted in something other than very large print and/or very slow speech.

5.3.6 Importance of confirmation of any assumptions

When a person is using this discovery tool in cooperation with a teacher, professional, or any other practitioner, this first stage might go faster if hints are provided by the practitioner. However, the tool would be designed so that it would not assume that the practitioner was correct. The tool would always use the hints from the practitioner as a starting point but would always confirm the best language, modality, size, scan rate, speech rate, etc. independently since an assumption by the practitioner can have profound negative effects on the overall evaluation of the user's needs if it is inaccurate. In fact, confirmation of all tool results will be necessary as part of the process to ensure a valid result and to recover from misleading responses from the user. Only after the language, preferred modality, and limits on the preferred modality are established and confirmed, as well as a reliable response mechanism can the general evaluation of user preferences commence.

5.4 Preference Discovery

In reviewing available preference discovery and refinement systems, some promising strategies and approaches surfaced, including:

- **Decision support strategies.** There are well-developed strategies that limit the steps required, or improve the efficiency in, arriving at the best or desired preference choice for users. Among these is a strategy called trichotomous branching, which is used in OTFACT—a tool that measures assistive technology outcomes. Trichotomous branching constrains the questions that are asked of users during preference assessment, based on the answers to previous questions (Smith, 2002). A trio of questions is asked where the choices are of the form "no problem," "some problem," and "can't do at all". For example, users may have no problem seeing text on screens, some problems seeing text on screens, or cannot see at all. The first and third options allow one to skip all of the questions dealing with settings and features to make it easier to see text on a screen. If the answer to the second question is yes, then another set of trichotomous questions is asked to eliminate or indicate more questions and options for the user. Another strategy is successive approximation, where the system guides the user through iterative refinements until a satisfactory decision is reached.

- **Games.** Games can be used as a means of engaging the user in preference discovery. Games encourage exploration, experimentation and risk taking while allowing valuable information to be gathered regarding what works and what does not work for the user.

- **Data-driven tools.** Tools that measure user performance on tasks and provide this data as feedback to users to guide their preference choices are powerful decision-making instruments that also increase self-awareness.

- **User interface integration.** Mechanisms that integrate preference choices directly into the user interface provide efficient means of adjusting preferences. These include control panels that may be contextually responsive, offering choices relevant to the task at hand.

- **Smart prompts.** If judiciously applied, smart prompts that do not break the user's focus on the task but offer helpful suggestions and observations that are customized to the individual user can be helpful in making preference decisions and refinements. Examples include observations regarding repeated patterns that might be achieved through the creation of shortcuts.

5.5 Matching Preference Sets to Interfaces, Content, and Tools

As outlined above, preference discovery and the formulation of preference statements for specific contexts and goals is one step in a larger process toward individually optimized accessibility. Individualized accessibility requires processes for delivering what each user needs, within a given context, for a given goal. There are many ways in which this can be achieved. These include but are not limited to:

1. programmatically re-configuring, restyling or reorganizing digital resources or user interfaces,
2. locating resources from searchable repositories of diverse resources to find a match,
3. combining resources to arrive at a match, or
4. generating content or configurations through services or crowdsourcing to address gaps not met by 1, 2 or 3 above.

Locating existing resources that match user preferences is supported by resource metadata that describes the accessibility preferences a particular resource can fulfill. Both the ISO 24751 standard and the IMS AccessForAll specification include an outline of this second half of the matching process. This information is also embedded in the proposed A11y metadata schema submitted to schema.org, which promises to embed this search criterion in mainstream search engines. The use of metadata to match preference sets to interfaces, content, and tools is described in detail in Appendix B.

5.5.1 Refining preferences

Once a match is attempted, the user or their support team can provide feedback on the success of the match in addressing their accessibility needs. This feedback can be used to refine the match, but also to refine the preference statement. As discussed in the next section, aggregate feedback from multiple users can be used to refine both the understanding of what works best for a particular user and what resource or user interface configuration best matches a specific stated preference.

This feedback data also has the potential to address critical knowledge gaps regarding individuals with disabilities in several domains. One domain is education. Standard educational research frequently eliminates data regarding the learning outcomes of students with disabilities as noise in a data set. Individuals with disabilities are so diverse that it is difficult to reach statistical power to draw any transferrable conclusions. The AccessForAll process enables the aggregation of a large corpus of individualized data on what does and does not work best for individuals with disabilities.

5.5.2 Paradata: Dynamic metadata

Paradata is usage data about learning resources that include both quantitative metrics (e.g., how many times a piece of content was accessed), as well as pedagogic context (as inferred through the actions of educators and learners). The term was originally coined by the National Science Digital Library project [http://nsdlnetwork.org/stemexchange/paradata]. Paradata about the preferences of users who found a resource worth using could, for example, be utilized by recommendation engines to suggest that users with similar preferences will also benefit from that resource. Manually producing metadata for large collections of resources is time-consuming. Currently, web-based resource providers often do not supply ample basic metadata about their resources, let alone accessibility metadata.

A few initiatives have emerged that are attempting to reframe opportunities for collecting and even inferring the data by leveraging paradata patterns. In actualizing this vision, for example, a large collection of paradata could be built up as teachers and learners select, recommend, and combine resources in novel and repeated ways. These patterns of use, sharing and peer recommendations will establish information about which resources are meeting particular user needs and preferences. This process is like recommender tools on shopping sites and library catalogues that indicate to the user: "People who viewed this item also viewed these items." Paradata for accessible education resources could be used in conjunction with educational resource properties such as those proposed by the Learning Resources Metadata Initiative (see *Web Schemas/Learning Resources* at http://www.w3.org/wiki/WebSchemas/LearningResources) to maximize resource fit.

A paradata system can aggregate large numbers of ratings or usage patterns so that information that helps users find resources emerges. One example is the Learning Registry [http://www.learningregistry.org/], a joint effort of the Department of Education and the Department of Defense. The Learning Registry is an open source technical system that hopes to have both paradata and metadata about the many learning resources available on the Internet supplied to it by many partners, including both private and non-profit providers of learning resources. In the context of open educational resources, tools such as the OER Quality Rubric tool on OER Commons (created in partnership with Achieve) have been developed for sharing refined quantitative and qualitative paradata with the Learning Registry.

These tools identify granular aspects of learning resources such as ratings for "degree of technological interactivity" that guide a better resource match with particular learning outcomes, educational standards, and assessment items. Rubric tools provide more targeted matching than paradata elements such as "number of views" which are useful in determining popularity of a resource but not fit. Extending these systems to include assessment of degree of accessibility provides a promising model for gathering data on exactly what aspects of resources are inaccessible. These systems also empower end users and practitioners with mechanisms for expressing demand for specific resource alternatives.

5.5.3 Responsive preference adjustment

The World Wide Web Consortium is now developing a vehicle to deliver user preferences from the browser to a web application called the W3C Indie UI User Context [https://dvcs.w3.org/hg/IndieUI/raw-file/default/src/indie-ui-context.html]. Although only in draft form, this specification is intended to deliver a subset of the information needed to match a learner's user needs and preferences with content on the Web. Its power, however, is to allow the device to manipulate the preferences based on the context in which the devices is operating. This ability is critical for mobile devices. Functional needs, such as the need for subtitles, can be set as a result of a poor signal to noise ratio impacted by significant background noise.

6 Implications of the Research

The findings have an impact on how we move forward with our conceptualization and design of the Preferences for Global Access (PGA) solution. As a result of this research, we are able to state both the guiding principles for development of a global access tool and the architectural structure of that tool. These aspects and next steps are discussed further below.

6.1 Guiding Principles

The research findings outlined in Section 5 above point to a number of guiding principles for addressing the needs of a diverse set of users.

- **Design for diversity.** One of the most important lessons gleaned from current practice and research is that we must design the preference discovery environment to address the diverse needs and contexts of users. The language used, the user experience offered, the complexity and specificity of choices offered, whether choices are made independently or with the help of professionals or other supportive personnel must be tailored to the individual, their goal and context.

- **Avoid stereotyping or assumptions based on disability classifications.** Medical diagnostic categories or impairments are not helpful in determining user requirements or preferences and frequently lead to inaccurate assumptions about a user's needs and preferences. Knowing that a user is "blind" does not address whether the user prefers Braille or speech for example. Disability is only one characteristic that influences a user's preferences and may not be the most influential or predictable determinant. If choices must be classified, functional classifications should be used (e.g., alternative to visual information).

- **Consider all facets of the user.** Numerous factors impact a user's needs and preferences not just factors related to disability. Contextual factors, environmental constraints, goals and motivations, role played, assistance available and other factors should all be considered in the preference discovery environment when the information is available.

- **Encourage exploration, experimentation and risk taking.** The preference environment should overcome the user's fear of breaking the system. All actions should be reversible, and the user should be made aware of the reversibility—to increase confidence in exploration. The user should also be able to completely back out of a set of preferences and go back to a previous version. In short, the user should be encouraged to play and make mistakes, and should be supported in trying out new strategies.

- **Demonstrate the chosen preference wherever possible.** Realistic simulations of specific preference choices or instant implementation of preferences assists the individual in “visualizing” the choices, understanding the implications of the choices and judging whether the choice is suits her/his individual needs.

- **Integrate usable decision support wisdom.** Data on what has worked in similar circumstances or what preferences best match a specific requirement should be judiciously communicated to the user in such a way that it is not overwhelming or prematurely biases the choices the user makes. This could also include features that enable users to communicate directly with peers, experts, and leaders.

- **Ensure that users are informed of preference decisions made on their behalf.** Any decisions or choices should be with user consent. A user may express a preference to forego notification of more minor decisions but this should be reversible.

- **Integrate into workflow.** Wherever possible preference decisions should be integrated into the workflow and context of the user experience. The user should be offered the option to make just-in-time decisions and should not be required to disrupt processes to adjust preference choices.

- **Enable continuous refinement.** The user should be enabled to continuously refine preferences settings and choices, to choose context specific or session specific preferences and to choose more generic or global preferences.

- **Provide extensibility and accommodate the unexpected.** Preference discovery environments should allow users to express new preferences that may arise for them, and to discover potentially unanticipated and unexpected preferences they may have, through, for example, search functionality that offers sets of preferences mapped to users’ search terms.

6.2 Architecture and the Discovery Tool

Based on our experience researching and designing preference editing tools over the past decade, it is clear that no single design will meet the needs of all users. There is an incredible diversity of experience levels, comfort with technology, ability, age, and other factors that influence the design of user interfaces for preference discovery. We need to speak the language of learners, giving them an environment in which they feel comfortable discovering what they need and experimenting with new settings. The PGA software architecture needs to take into account this diversity, making it easier for designers and developers to create different user interfaces for different users.

To this end, we envision an ecosystem in which there is a selection of preference editing user interfaces and tools available to users, each with a particular strength or approach. These editors are listed in Appendix A, along with a draft of the system architecture into which the preference tool—called the Discovery Tool—will reside. A more detailed system architecture will be developed for the second deliverable of this project that will accompany the Discovery

Tool prototype to be developed. However, to provide context it is important to summarize some of the key components of the system architecture used to support the Discovery Tool and its dependency on browser enhancements yet to be developed that are missing today but are needed for the final Discovery Tool.

The PGA software architecture supporting the PGA Discovery Tool is based on the Global Public Inclusive Infrastructure (GPII) system architecture and will provide the following services:

- A preference server
- A user authentication framework to facilitate preference gathering and IT content adaptation and selection based on user preferences
- A flexible UI Component Library that will facilitate content adaptation
- A Scaffolding Framework on which to build tools that can be injected into delivered web applications to create and deliver a broad range of functions needed to assist users. Examples of tools include bread crumbs, reminders, and site maps
- Full and Quick Preference Editors
- Matchmakers used to match resources, such as web content, to users needs.
- An Enactor Framework that allows content delivery to respond to user preferences such as activating subtitles throughout the current web page.
- A flexible UI Option Panel on which to build settings tools such as the Discovery Tool
- A persistent data store for storing user preferences
- A FlowManager to allow an application to access GPII services to facilitate adaptation to meet a user's needs.
- Native platform accessibility features including matchmakers, assistive technology catalogs, and browser plug-ins

The PGA Discovery Tool, discussed further below, is a key component of the overall GPII strategy, and is designed to assist the user in discovering their needs through a variety of means that will improve their experience on the Web.

6.3 Next Steps: The Prototype

Building on the research and expert feedback, we recognize that the overarching design challenge must address the question: *How do you design a discovery tool that is accessible when you don't know what the accessibility needs are in the first place?* In answering this question, the next phase of this project will entail the delivery of a prototype of a browser-based Discovery Tool. The design team has created the Discovery Tool to be a playground for exploring and discovering preferences. This tool seeks to *get users in the door* of preferences editing, and allows them to improve their experience on the Web.

The Discovery Tool lets users discover and express their preferences in their own terms, and on their own terms. The tool is embedded within the page of content that the user is interacting with. The tool meets the user wherever he/she already is—there are no confusing modal changes. While engaging with the content, users can explore various "presets," or collections of preferences that will change the content automatically. During this exploration the Discovery Tool helps users gently experience transformations that they may not have been aware were possible or might not have been aware were helpful.

The presets are based on the customizations possible with the content. For example if a page that a user is viewing has video content, then the presets will be related to transforming video, if the page is mostly text, then the presets will be related to text alternatives or transformations. Presets may also vary among devices, such as a website on a desktop versus an interactive on a kiosk. The vision is that discovery tools can be tailored with presets that reflect the available content enhancements and alternatives for the content and device.

Activated presets from the Discovery Tool show an immediate change to the content the user is interacting with. The user can quickly and easily de-select the preset to return to the original presentation or can choose a different preset to explore more transformations. If the user discovers a preset that he/she wants to save and reuse, he/she can create an account and save the settings to the cloud (see Appendix A). The tool then connects with the other tools in the Preferences Management ecosystem: the Full Editor and Quick Editor. Those tools continue the quest to *get users in the door* by avoiding categorizations (approaching needs and preferences from a medical model rather than an individual one), and instead providing features such as a powerful search that reflects a flexible ontology including: simple terms, technical terms, medical terms, etc. PGA research has revealed that systems are currently in widely varying stages of readiness for effective implementation of the Discovery Tool we envision.

Deliverable 2, which will present the prototype work for this project, will include a pragmatic demonstration of transformations that are possible in the near term in the OER Commons environment as an example of a content delivery system in the learning context, capable of supporting preference match-making. This will include an analysis of which transformations are possible today at the browser or operating system level and which must be implemented on a content delivery system basis. Details about the prototype will be presented and explained further in Deliverable 2 (the first draft of which will be submitted on July 23, 2013).

7 Conclusions

It is clear that even in the most optimal conditions, many individuals with disabilities are not receiving the assistive technology features they require to participate fully in society or to achieve their full potential. The research in this project has shown that to reach the broadest number of users with the most optimal solution, a personalized approach that takes into consideration a broad range of user preferences must be employed. Virtually all accessibility compliance criteria today target a one-size-fits-all approach. The customization and modification settings used to meet this approach are insufficient to reach the broadest user sets. Furthermore, this approach to access focuses on very specific medical definitions of access needs and typically ignores the diversity of disability as well as disability that is less obvious such as cognitive impairments.

An important outcome of this research is the definition of the individual requirements for what is needed for cognitively impaired users. This broadening of inclusion could not come at a more opportune time as personalization constructs and enhancements to the Web Content Accessibility Guidelines have just now begun. Furthermore, the move to mobile IT delivery will make the need for these new accessibility compliance criteria mainstream technology drivers.

Additionally, this research has helped to inform the important challenge of how to capture the needs of a diverse, comprehensive range of users, and how to support how they best learn about possible preference settings. This project has shown that preference discovery requires tooling that minimizes the time spent in the tool; engages the user; prompts the user only as needed; allows the user immediate access to changing those preferences; includes decision making tools that foster self-awareness; allows the user to decide if the changes they have made improve their experience and if necessary allows them to easily back out of the decision without fear of harming what has worked best for them. This design is in contrast with preference setting in today's systems which target a limited set of users, are often hard to find and access, and due to the limited set of users they target, are unable to build a good-fitting solution for most users.

Finally, this research has contributed to an increased understanding of how to enable people to move through the creation of digital presets, which can be used to configure the system when the user is faced with too many obstacles in engaging with the preference discovery at all. This management of a "cold" start to preference setting is extremely important for provision of global access.

On the whole, this report points to gaps in existing technology. Key assistive technology, such as the ability to read digital math for the blind and users with attention deficit, are limited to proprietary solutions that are constrained to one browser on one desktop platform. Browsers also do not render essential digital math, such as MathML, directly requiring content delivery systems or browsers to render it using a plug-in or through modifications to the content delivery systems. An investment in open source browser math verbalization tools must be developed with a push to get MathML rendering in all of today's browsers or leave the responsibility to education solution providers. Due to these limitations we know the prototype will require considerable enhancements beyond this phase, as we introduce the broader range of assistive technology required for diverse user needs, including cognitive needs. Finally, there is a need for further development of systems to empower end users and practitioners with mechanisms for expressing demand for specific resource alternatives, given that web-based resource providers often do not supply ample basic metadata about their resources, let alone accessibility metadata.

The next phase of the PGA project provides an important starting point for further investment to address the gaps and opportunities identified in our research. The PGA project builds upon the AccessForAll personalized approach to digital inclusion and has the potential to increase consumer self-awareness and autonomy, to recognize the full spectrum of user needs, to acknowledge the uniqueness of each individual, to support AT professionals in delivering more comprehensive services, and to provide an approach that benefits users with and without disabilities. In sum, the findings in this report underscore the PGA project's inclusive approach to accessibility, where AT assessment, training, and delivery are mainstreamed, and where disability and accessibility are treated as relative conditions—which ensures that these processes are more resilient, up-to-date, and inclusive.

Appendix A – System Architecture for Preference Editing and Discovery

Based on our experience researching and designing preference editing tools over the past decade, it is clear that no single design will meet the needs of all users. There is an incredible diversity of experience levels, comfort with technology, ability, age, and other factors that influence the design of user interfaces for preference discovery. We need to speak the language of users, giving them an environment in which they feel comfortable discovering what they need and experimenting with new settings. The Preferences for Global Access (PGA) software architecture needs to take into account this diversity, making it easier for designers and developers to create different user interfaces for different users.

To this end, we envision an ecosystem in which there is a selection of preference editing user interfaces and tools available to users, each with a particular strength or approach. Several of these editors are already in development within the larger Global Public Inclusive Infrastructure (GPII) effort –for example, as part of the Cloud4all, Flexible Learning for Open Education (FLOE), and other projects, including:

- A *full editor*, which gives users the ability to see and edit all of their preferences for any device, application, or context. This interface will be optimized for larger screens and more focused, less frequent usage.
- The *quick editor*, which provides users with an easy means to adjust their needs and settings on the fly and in context of the content they are currently working with.

And within this PGA project:

- The *Discovery Tool*, which is the primary focus of the PGA prototyping effort. The Discovery Tool provides users with a safe means to explore, discover, and experiment with the range of preferences, alternatives, and adaptations available to them.

Given this diversity of preferences editing tools, a primary concern is to ensure that there is technical consistency and reuse across all of these tools. There is no reason to incur the cost of redundant or duplicative efforts, as well as potential confusion for users that typically result from ad-hoc development. Instead, developers of these preferences editing tools need robust building blocks which can be shared and reused throughout the ecosystem, ensuring that users are provided with stable, comprehensible, and consistent user experience.

To this end, the PGA architecture, in tandem with the international efforts of the Cloud4all and FLOE projects, will contribute to the specification of a *GPII Preferences Framework*—a reusable set of schemas, programming APIs, and UI building blocks—that will be employed in the development of each of the preference tools in the ecosystem, including the PGA Discovery Tool within OER Commons.

The GPII provides a robust and comprehensive architecture designed to support the personalization of desktop, mobile, and web applications. The scope of this architecture is specific to the creation, persistence, and integration of preference editors into a variety of web-based applications, content management systems, and delivery environments. It is not intended to address the specific details of how content is delivered to users, nor how it is adapted to fit their needs and preferences. To address this, content system developers may choose a variety of strategies; the Discovery Tool architecture provides an event-driven API that enables them to listen for changes in a user's preferences and settings and respond accordingly.

Security and Privacy

A user's preferences may reveal personal information about their lives and needs, either directly or indirectly; privacy and security is thus of critical importance to the design of the PGA architecture. This is another case where the project will closely follow the approach established by the GPII. While the security and privacy infrastructure work is still in its early stages, the intention is to use—for both projects—the OAuth 2.0 framework to protect access to a user's preferences by third party applications. These third party applications will include web sites, content delivery tools, and OER authoring environments such as OER Commons's Open Author, which will implement PGA.

The use of OAuth will let users approve or deny access to their information on a per-site basis, ensuring they control who gets to see and act on their needs and preferences. In designing this system, the PGA architecture will strive for compatibility with efforts such as the National Strategy for Trusted Identities in Cyberspace, a White House initiative focused on the establishment of an identity ecosystem that will allow individuals to validate their identities securely to facilitate exchange of personally identifiable information such as accessibility preferences. This layer of protection is particularly critical for the exchange of data indicating medical needs of users (such as the need to use a screen reader) in contexts where that information may be exposed to third party applications unbeknownst to the user.

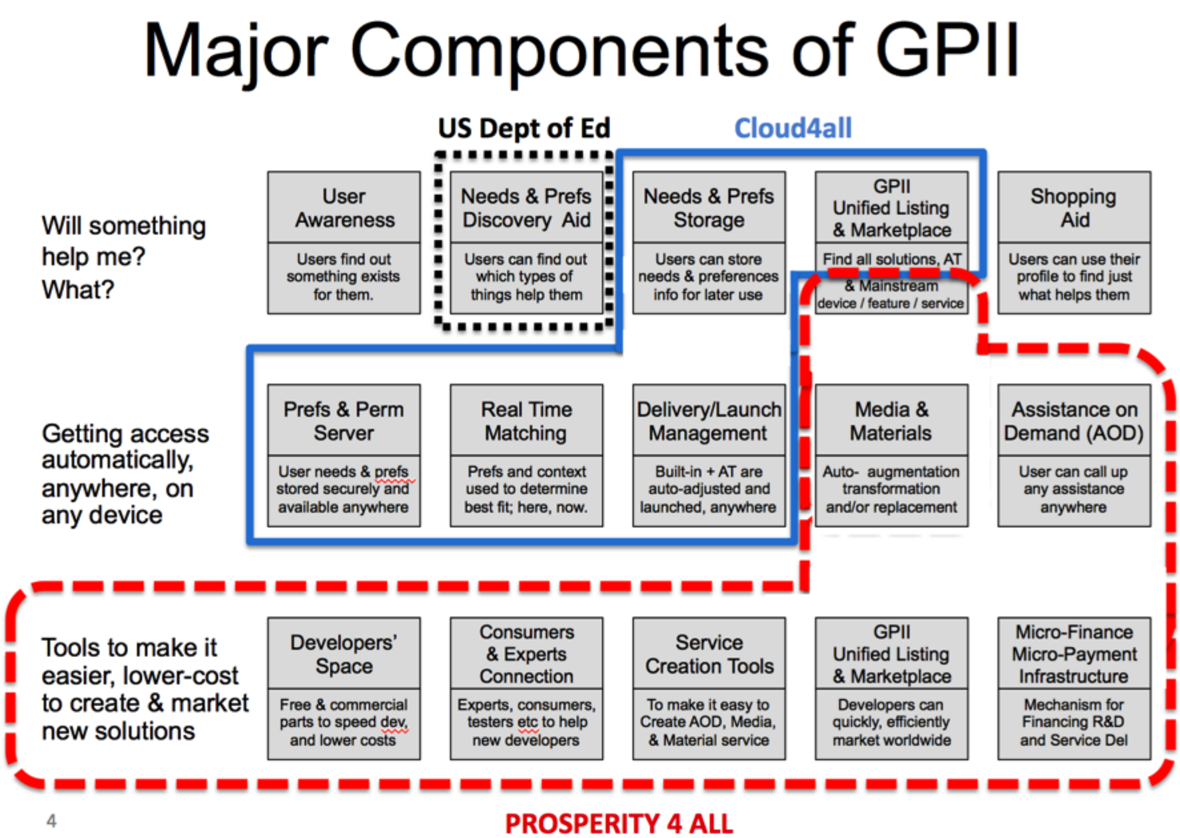
In the future, an attribute release layer such as the Kantara Initiative's User Managed Access will be layered on top of the basic OAuth 2.0 authorization system (Machulak 2010). This will give users the further ability to specify that a site or application is able to see only portions of their preferences set, ensuring that the risk of "privacy leakage" is reduced by only sharing the minimum information required by a service to meet users' needs (Krishnamurthy 2009).

The goal is to ensure that the architecture can support diverse privacy and security requirements internationally.

Architectural Components

Figure 1 shows an overview of the GPII and its relation to PGA, as well as Cloud4all and Prosperity4All. The GPII has three major functions, each with five major subcomponents. All of these components are essential to ensure that solutions exist, and that people of all ability levels and financial levels can discover what works for them and have it appear on every device they encounter and have to use. Central to the PGA work (noted as "US Dept of Ed" in the figure) is the preferences discovery aid, or tool, where users can identify what solutions will help them.

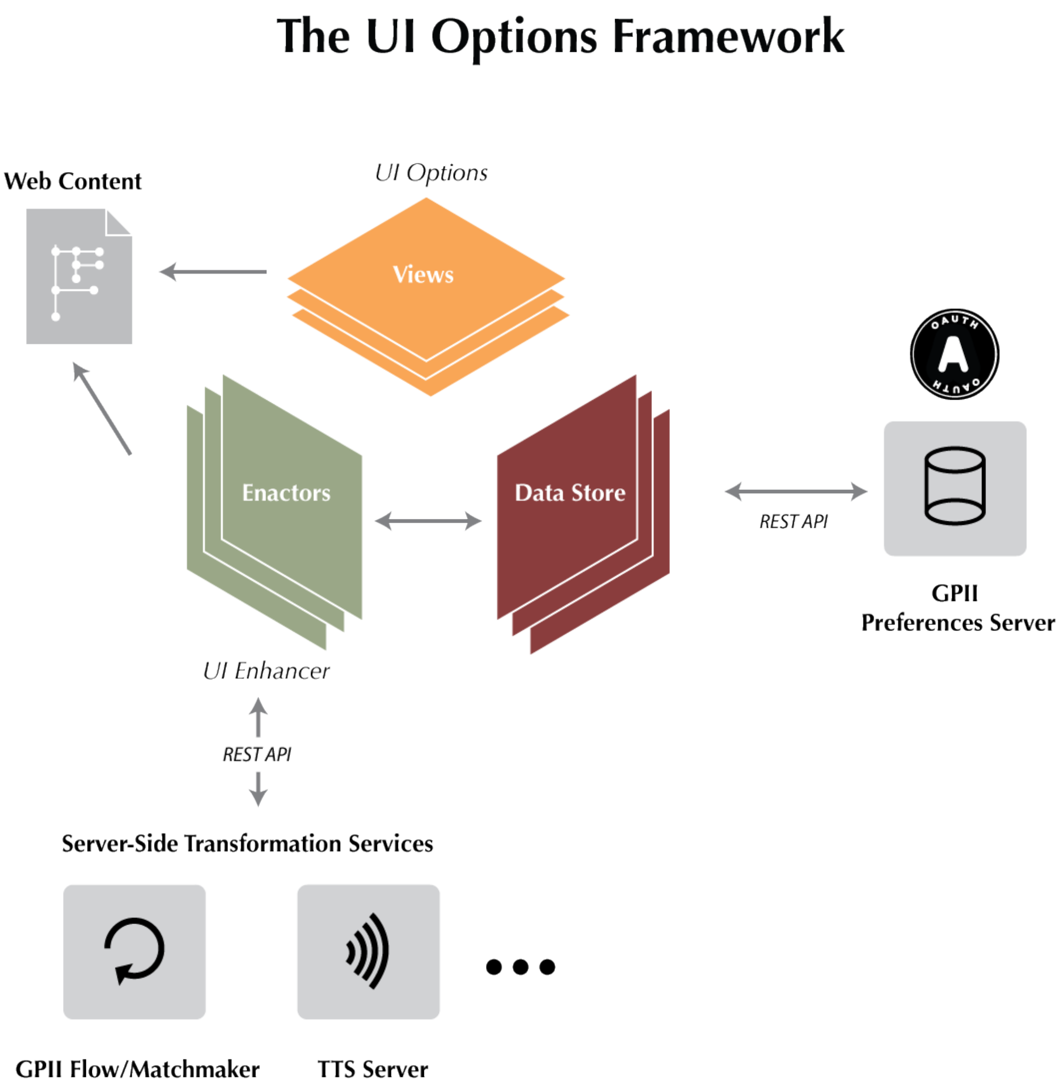
Figure 1: The Global Public Inclusive Infrastructure and its relation to *Cloud4All* , *Prosperity4All* and the *Preferences for Global Access*



UI Options Preferences Framework

User Interface (UI) options are a component that ships with the Fluid Infusion application framework. It is currently being extended to serve as much more than just a UI component; UI options provide a programming framework with which new user interfaces for editing preferences can be more easily built. The goal is for UI options to provide all the lifecycle events, configuration hooks, and persistence infrastructure required to support a variety of different editing experiences, ensuring that there is a robust and well-tested framework in which to incrementally move the PGA designs from prototype to production. The UI Options framework is described in further detail below.

Figure 2: Primary architectural components of Preferences for Global Access, including the UI options framework, the GPII Preferences Server, and server side transformation components.



GPII Preferences Server

The GPII Preferences Server represents a cloud-based service for storing and retrieving user preferences in a secure manner. Preferences are stored within the preferences server in a JSON format that is compact and easy to parse by a wide variety of tools. In order to enable broad compatibility and "available anywhere" portability, the GPII preferences server will be used as the primary means for persisting user preferences within the Preferences for Global Access architecture (for additional information, see Clark & Basman, 2012).

Server-Side Transformation Services

Many user preferences can be enacted using client-side web technologies (for example, large print or high-contrast themes can be applied using CSS), and this will be the default approach for the PGA architecture. However, there are cases where current browser technology is unable to accommodate a user's needs and preferences directly with HTML, CSS, or JavaScript. Text-to-speech is an example of this, where browsers don't yet have the ability to synthesize speech directly. In these cases, server-side transformation services such as a text-to-speech server using the open source Festival engine will be built. The key architectural approach here will be to leverage server-side JavaScript with Node.js and Fluid Infusion so that, as browsers rapidly improve, logic can be more easily ported from the server-side to the browser.

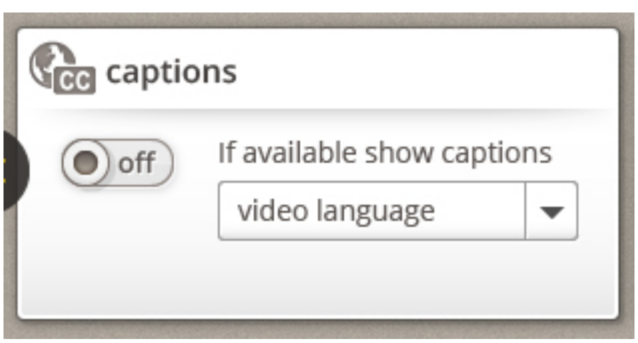
A Framework for Extensible Preferences

The UI Options framework is intended to give developers the ability to supply custom appearances, behaviours, and schemas for any preference, including new preferences that are not part of the default UI Options package. This is achieved architecturally by modeling each preference as three discrete objects: a View (presentation) component, an Enactor (action) component, and a Persistence component. This three-part model ensures that developers and designers who either are integrating UI Options into their site *or* who are using it as a general framework for building their own preferences editor (such as the PGA discovery tool) have complete control over how a preference 1) appears to the user, 2) is enacted, and 3) is stored.

Figure 3: Diagram showing the architecture of preferences within the UI Options framework, including presentation, action, and persistence.

For example, let's consider the process of adding a new preference to the framework: closed captions and subtitles for videos. The user interface this preference might be designed with two controls in it: a stylized on/off switch that allows the users to turn captions on and off, and a drop-down menu allowing them to select their preferred language. Here is an illustration:

Figure 4: A user interface for turning captions and subtitles on or off and selecting a preferred language for them.



From a technical perspective, when the Captions preference is enabled, all video players should automatically show closed captions if available. In practice, this might be accomplished by creating a JavaScript component that automatically finds supported video players on a page and invokes their API to turn on captions or subtitles.

So, from an architectural perspective, the developer who is creating this new preference will need to specify three things:

1. A View component that represents the panel. It will specify the markup, styling, and rendering required to show the dropdown menu and switch/checkbox.
2. An Enactor component, which will do the work of finding all video players on the page and enabling captions or subtitles for them.
3. A Schema, which defines default values for each of the settings. In this case, the preference might default to "off" and the language might default to user's browser locale.

In each case, the UI Options framework provides a declarative JSON data structure for registering custom components, enabling easy customization of a preferences editor by third-party developers and integrators without having to modify any built-in code. As a result, the job of the developer is to compose preferences together into a tree of JSON configuration that is passed to the UI Options framework at instantiation time.

By separating the responsibilities of view and action, this architectural approach will enable developers to more rapidly create diverse preference editing experiences. For example, a designer may want to provide both a highly simplified user interface that is more fun and approachable for children as well as an in-depth experience for more technical users. In this case, the same Enactor code can be reused while different Views can be written and swapped in without having to change any core application code.

The UI Options framework also provides support for pluggable previews, enabling a user to see the effect that a preference change will have before committing to it. Developers can provide their own custom preview strategies. The default "live preview" strategy shows the changes applied to a live view of the application, allowing users to see their preferences in context. Another built-in strategy included is a "sample window" preview showing a small selection of typical content. We also envision specialized previews where the user can try out the preferences in practice in a safe environment before committing to them globally.

The View

The View component is responsible for specifying the markup, styling, and template required to render the panel. Here's an example of what the declarative view specification might look like for this CaptionView component if it used the Infusion Renderer to present its markup:

```
fluid.defaults("fluid.uiOptions.views.captionView", {
    gradeNames: ["fluid.uiOptions.view", "autoInit"],
    strings: {
    language: ["English", "French"]
    },
```

```
            controlValues: {
            language: ["en", "fr"]
            },
            produceTree: "fluid.uiOptions.views.captionView.produceTree",
            resources: {
            template: "{templateLoader}.resources.captionView"
            }
    });
```

The Enactor

The Enactor does the actual work of accommodating the user's preference. In the case of web application, Enactors are typically registered with the UI Options framework's UI Enhancer component, which is responsible aggregating multiple Enactors together and managing the interaction between these Enactors and the page's Document Object Model (DOM).

Enactors can be of arbitrary complexity. In many cases, an Enactor may well manipulate DOM elements directly (such as a content simplifier that removes HTML5 and WAI-ARIA landmarks such as "banner," "footer," and "navigation" while leaving the "main" content untouched). In other cases, such as this closed captions example, the Enactor may delegate the actual work of performing the action to another module (such as an HTML5 video player component). Here's an example of how a developer might configure a UI Enhancer component with this new closed caption and subtitles Enactor along with others:

```
    fluid.defaults("fluid.uiEnhancer.defaultActionsWithCaptions", {
            gradeNames: ["fluid.uiEnhancer", "fluid.uiEnhancer.browserTextEnhancerBase",
    "autoInit"],
            components: {
             captions: {
    type: "fluid.uiOptions.enactors.captionsEnactor",
             container: "body"
             },
             textSize: {
    type: "fluid.uiOptions.actionAnts.textSizerEnactor",
    container: "{uiEnhancer}.container",
             options: {
             fontSizeMap: "{uiEnhancer}.options.fontSizeMap",
             sourceApplier: "{uiEnhancer}.applier",
             rules: {
```

```
 "textSize": "value"
          }
          }
          },
          ...
 }
});
```

Persistence Information

The Persistence component provides schematic information about the preference—-its value types, ranges and default values. Developers can also plug in custom **Data Store** components, which enable the preferences editor to connect to different data stores. Several default Data Store objects ship with UI Options out of the box, including one that will store the user's preferences in HTML5 local data storage, one that saves the preferences directly into the GPII cloud-based Preferences Server, and a temporary one that is suitable for testing.

Here's an example of what a simple schema component might look like for our closed caption and subtitles example, including a set of default values and a JSON Schema (Zyp, 2013) [http://json-schema.org/latest/json-schema-core.html]

:

```
fluid.defaults("fluid.uiOptions.mediaSchema", {
          gradeNames: ["fluid.uiOptions.schema", "autoInit"],
          defaultModel: {
           captions: false, // boolean
          language: "en" // ISO 639-1 language code
          },
          schema: {
          properties: {
          captions: {
          type: "boolean"
          },
          language: {
          type: "string"
          }
          },
          required: ["captions", "language"]
```

```
        }
    });
```

Suggested Approaches for Content Delivery and Adaptation Technologies

While the scope of the PGA architecture's APIs and component models are specific to the process of editing and discovering preferences, this nonetheless involves an interaction with a content-delivery mechanism. The following is a set of guidelines and suggested approaches for content delivery system developers in order to ensure that they are amenable to providing personalized user interfaces and resources based on a user's needs and preferences.

The Web: Given the diversity of platforms, tools, and devices that users are increasingly using at work, in the classroom, and at home, the Preferences for Global Access architecture needs to be broadly cross-platform and compatible. Web technologies such as HTML, CSS, and JavaScript are ideally suited to delivering cross-platform, cross-device user interfaces without requiring extensive code to be written for each new platform. The PGA architecture embraces these standard tools on both the client and server (typically with Node.js), making it easier to integrate our preferences environment into the applications users use the most. Content delivery systems are encouraged, likewise, to embrace modern web technologies such as CSS and HTML5—particularly the use of responsive web design techniques and semantic tags that clearly denote the structure and organization of a page—in order to ensure their content can be adapted and scaffolded more easily.

Infusion: The PGA architecture follows Fluid Infusion's declarative Inversion of Control (IoC) philosophy, making it easier for third-party developers and designers to refine and extend the PGA's preferences discovery environment over time. With Infusion IoC, instead of writing code with tightly-coupled dependencies, developers express their application structure as a declarative "component tree" that is instantiated and managed by a context-aware framework (Basman et al., 2011). This makes it possible to change the application later, either statically by third-party developers or at run time by evaluating contextual information such as device capabilities and physical sensors. Content delivery system developers are encouraged to leverage the context-aware features of Fluid Infusion as well as the rigorous separation of content from structure afforded by the Fluid Skinning System (FSS) in order to create content that can be automatically by the preference discovery tool and other UI transformation services.

Integration with GPII Preferences Server and Flow Manager: The Preferences for Global Access architecture is, as mentioned, closely aligned with the overall Global Public Inclusive Infrastructure. As part of this effort, a robust and comprehensive architecture has been designed to support the personalization of desktop, mobile, and web applications. In future versions of the Discovery Tool, users will be able to explore and discover preferences and adaptations not only for web-based content but also native platform tools such as assistive technologies like screen readers, screen magnifiers, and system keyboard response settings.

Further information about the GPII's architecture for web, desktop, and mobile personalization, including the configuration of assistive technologies, is available in the GPII wiki [wiki.gpii.net].

One of the services that will be available soon as part of the GPII architecture is the Web-based Flow Manager, which allows web applications to integrate with the GPII Preferences Server and Matchmakers. So for example, a learning content delivery system can register itself as a personalizable application with the Flow Manager, describing its capabilities for meeting a user's needs and preferences. This is described in a JSON format consisting of "new" ISO 24751 metadata. Once registered with the Flow Manager and given an OAuth 2.0 application token, a web application can make requests on behalf of the user to fetch preferences from the Preferences Server and suggestions for adaptations from the Matchmakers. This, too, will be conveyed using a RESTful service API and JSON-based declarative payloads.

Content Delivery and Dependencies

A challenge with deploying a discovery tool capable of acquiring a broad range of user's needs is that their browser must be capable of interoperating with assistive technologies, have adequate support for Cascading Style Sheets, the ability to render digital math, and support for new features now found in HTML5.

The following browser standards are employed by the PGA architecture:

- W3C Cascading Style Sheets version 2
- W3C HTML5 tabindex
- W3C WAI-ARIA
- MathML

However, MathML rendering is currently sparsely supported natively at this time. To fill this gap, a cross-browser conversion utility must be provided that will convert MathML to SVG or HTML and CSS. In addition, we will integrate a Math voicing tool capable of speaking math expressions with navigation for users who are blind or simply experience improved math cognition through voice, such as users with attention deficit or some users with short term memory loss. Today, the recommended voicing tool is an Internet Explorer plug-in called MathPlayer from Design Science. Support for other browsers, such as Firefox, is planned for MathPlayer. Google is developing math reading capability for the Chrome Browser with ChromeVox, but it is in the very early stages.

Due to the cross browser limitations of these tools, and the clear importance of offering verbal access to digital math to all users, we believe that future funding is necessary to build an open source cross-browser solution for reading mathematical expressions targeted at a variety of users (including people who are cognitively impaired or blind). Also, due to the rendering complexities of mathematical expressions, we think that this tool should work with a Scalable Vector Graphics (SVG) rendering rather than one that uses HTML and CSS. SVG 2 will provide discrete objects in the browser document that can be referenced and navigated using the keyboard and it is designed for richer drawing capabilities.

Scaffolding, Widgets, and Content Augmentation

In addition to supporting preferences for the transformation and adaptation of web-based content and the configuration of assistive technologies (in cooperation with the GPII Flow Manager), the PGA architecture will also support a variety of "scaffolding" tools that assist in the learning process. Scaffolds can be dynamically injected into content when the user expresses a preference for them.

These tools are particularly useful for people with or cognitive needs, who may want additional help in managing time and focusing on the task at hand. For example, such scaffolds may include embeddable calendars, reminders, timers, alerts and alarms. Linguistic scaffolds such as a thesaurus, dictionary, or glossary helps when using text-heavy resources. Navigational scaffolding may include breadcrumbs, site maps, or other tools to help the user orient themselves within a site's complex navigation scheme.

The PGA architecture supports the creation and injection of scaffolds that conform to the Enactor API described above. Scaffold Enactors need not be limited to DOM-related transformations; they can easily query web services (such as a dictionary service, for example). In cases where scaffolds require persistent state, such as a set of alarms or timer intervals, developers may choose to store this state as part of the user's persistent preference set in the GPII Preferences Server, where they will be available in cloud for use across a variety of systems and sites. Although Preference Server-based persistence is strongly encouraged where appropriate, the PGA prescribes no specific constraints on how scaffold enactors choose to persist specialized state, so long as it does so in a manner that is consistent with the user's expectations.

Future Adaptation in response to device modified user context

Although now in the design phase, browsers will provide the ability to deliver user context information to the web and native applications that will be affected by user driven device settings and environmental factors. As our research has shown accessibility needs are not always medical in nature and may in fact be driven by mobile device, situational impairments such as low lighting conditions, inability to view the screen, low signal to noise ratios driven by background noise, inability to control the keyboard or touch interface due to location. This is something a preference server cannot do from a remote server. In these situations new mobile devices may need to change a user’s settings dynamically without user configuration by deliver modified preferences to an application.

The W3C IndieUI standards effort is developing a User Context specification that will define settings to be provided to a web application. When this specification nears standardization new versions of the GPII Matchmakers will need to incorporate these preferences with their normal decision making process to produce select an appropriate match when a situational impairment must be addressed over one that is static. Efforts are being made to harmonize the vocabulary in the Indie UI User Context specification with those that would be used in GPII and AccessForAll to facilitate the proper matching and GPII preference server overrides.

Appendix B – Metadata for Matching Preferences

Metadata related to accessibility of a resource provides a connection between user preferences and configuration of the interface, format of content provided, and tools supplied. Once a preference has been described, metadata can be searched to discover resources, services, content and interface configurations that fit the user's need. For example, if an alternative to audio is required by the user, then the system may respond by providing audiovisual resources that have captions or transcripts. Metadata to provide accessibility information about educational content and interfaces was first formalized in 2004 (IMSglobal.org/accessibility: AccessForAll Meta-data Specification) by IMS, with input from the Dublin Core Metadata Initiative, the W3C, and IEEE LOM and later standardized in the ISO 24751 standard. The standard has been used in learning management systems and other technical frameworks (ATutor, BarrierFree, EU4ALL, Web4All), in content repositories (Teachers' Domain, OER Commons, the National Science Digital Library, The Inclusive Learning Exchange (TILE)), in authoring tools that automatically create metadata about accessible materials (Boni, 2006) and in design patterns for learning objects (Green, 2006).

Accessibility metadata can be used in combination with preferences to aid discovery of accessible materials, to automatically adjust the presentation of materials and to augment inaccessible materials with supplemental resources. Metadata can also be used to repair inaccessible websites by allowing volunteers to provide supplemental information that users with disabilities can use (Takagi, 2008). These different processes are discussed further in the following sections.

Metadata for Interfaces

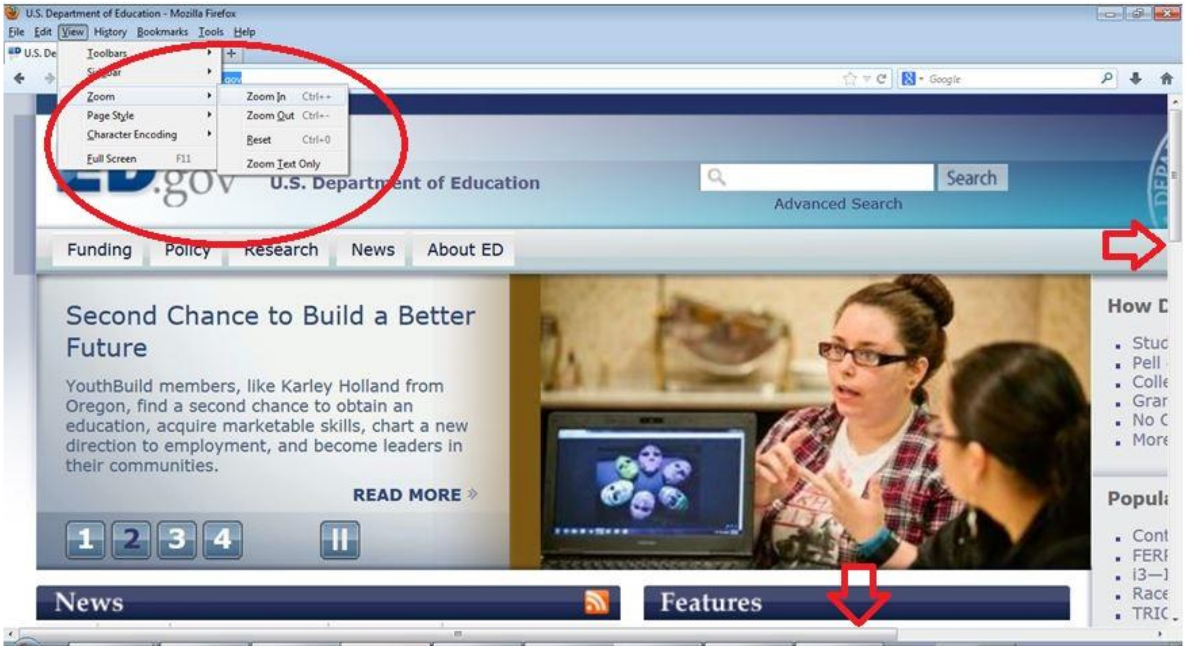
Some interfaces may be transformed without metadata matching. These kinds of transformations are carried out by embedded user interface (UI) options and device requirement code while other UI transformations are made possible through systems that can build custom interfaces. A common example of interface transformation is the option found on Internet browsers to transform the appearance of text. The following examples illustrate this feature in Mozilla Firefox 20 on a PC, the first image indicates how to locate and select for text size changes. In this first example, the viewer chooses to transform text only and leave images static. The second image shows the result of zoomed in text under this setting.

Figure 5: Interface transformation in Mozilla Firefox 20 allows the viewer to change text size.

Figure 6: Text in the browser is enlarged while the picture sizes do not change.

The Firefox transformation also allows for the entire page to be resized even beyond the screen dimensions. This transformation is illustrated in the following figure.

Figure 7: The text and images may be resized even extending the page beyond the physical dimensions of the screen.



Some websites also provide options for transforming the appearance of text. The following two screenshots illustrate this transformation feature, which is the Fluid project's User Interface options built into the website OER Commons. In this case, the options include text resizing, text style, line spacing, and contrast changes. The first image shows how this feature is typically presented on websites and the second image shows the selected contrast and text size changes.

Figure 8: Websites also build in user interface transformation features like the ones shown here which allow for text size and contrast changes.

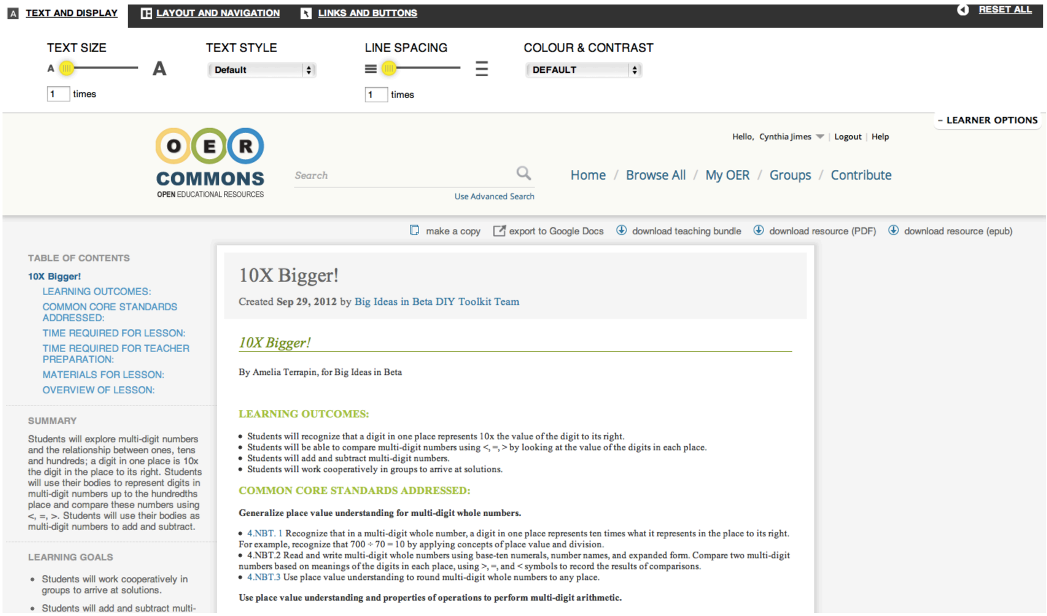
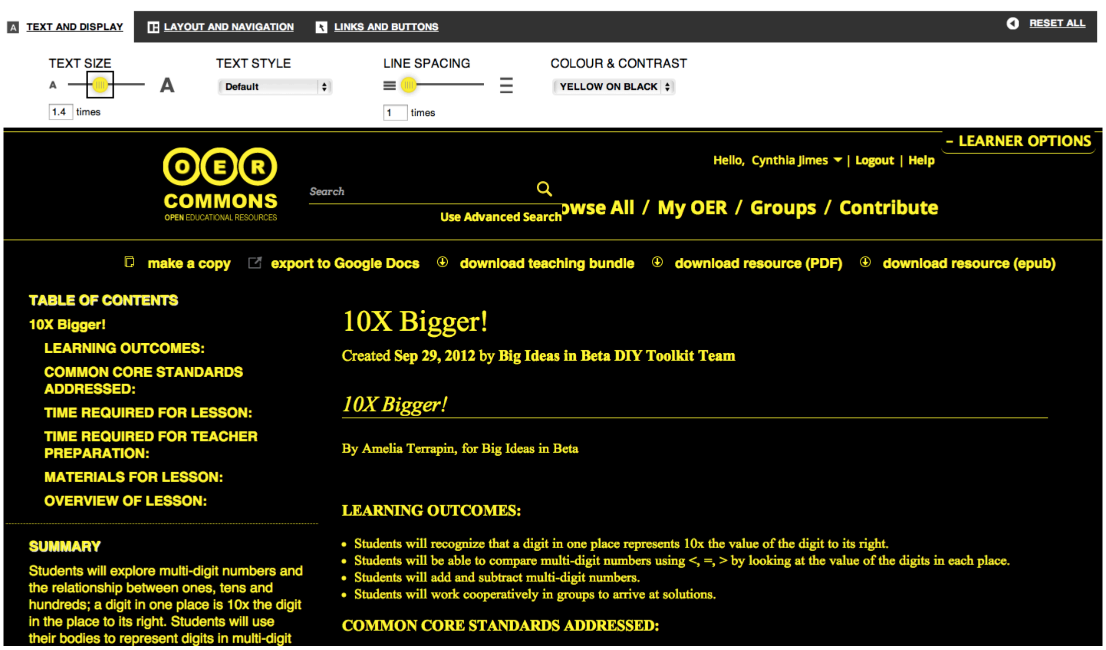


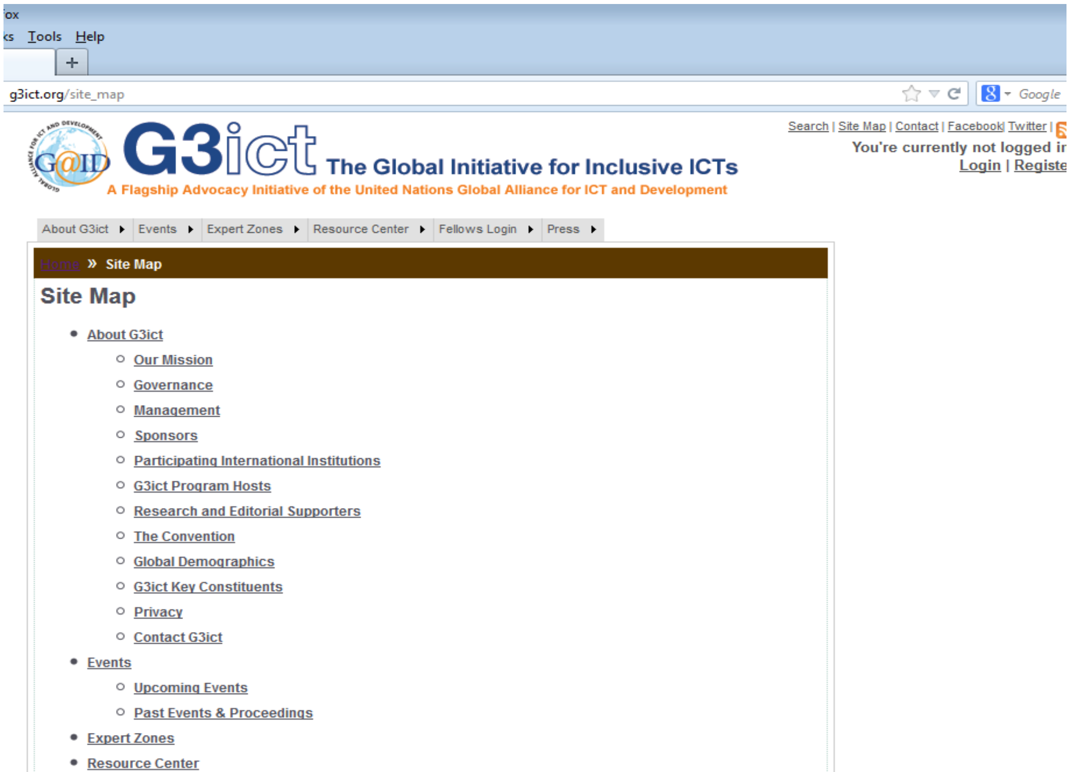
Figure 9: A viewer may find the web site transformations of higher contrast between background and foreground (text) as well as the larger font size makes it easier to read this page.



Other interface transformations that do not require metadata but can improve the ability to navigate a site by increasing the size of target areas for clickable links and generating a table of contents for the entire site. The images below demonstrate two ways of viewing a site: through the image-rich graphical user interface or the text-based table of contents.

Figure 10: G3ict site: Image-rich graphical user interface

Figure 11: G3ict site: Text-based table of contents

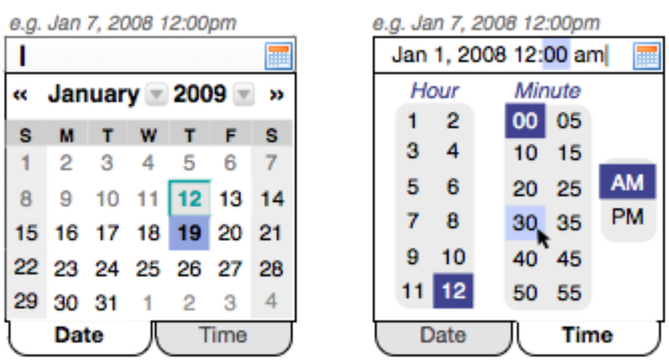


This transformation may be helpful for viewers for multiple reasons: it will be faster to download and read on small device screen, it will be easier to navigate with a screen-reader, it is easier to read for those who prefer a simple interface or have difficulty focusing on busy interfaces, it enables efficient navigation to deeper site pages, and it provides quick overview of the site content. The flexibility offered by these site features enables visitors to transform the content to meet a variety of needs for a diverse set of needs, contexts and abilities.

Interfaces may also transform automatically in response to the display needs of different devices. This approach is called responsive design. In this kind of transformation, the metadata match is between the interface (e.g. a web site) and the *device* metadata. For example, a web site that is displayed on a mobile phone may transform automatically or may prompt the visitor to consider downloading their mobile application or to elect to visit their mobile-optimized site. This capacity to use device metadata enables automated altering of the interface appearance for improved usability.

Perhaps the most transformative use of metadata for improved interface accessibility is matching declared user preferences to metadata of interface components to enable significant personalization and customization of the interface. An interface such as a website is built from multiple components that enable different functions. Some examples of these components are date-pickers, drop down menus, sliders and buttons. Component libraries can use metadata and preferences together to enable users to change the interface or to automatically build the interface with components that best fit the user's preferences. For example, the system can change a date-picker that works best with a mouse into one that is easily used from the keyboard, if a user's preferences indicate that they cannot use a mouse. The accessible date and time picker conceptualized for the Fluid project and illustrated below is an example of a component that could be rendered in an interface based on stated preferences for keyboard navigation.

Figure 10: This illustration of an accessible date and time picker enables either selection of the desired date and time through entry in the text box or through manipulation of the mouse.



This component enables the user to tab to the text box and enter the desired date and time rather than manipulate a mouse to select the desired date and time from the image-based calendar. Metadata that identifies features of the component such as its keyboard accessibility enable the system to match to user preferences and transform the interface as desired.

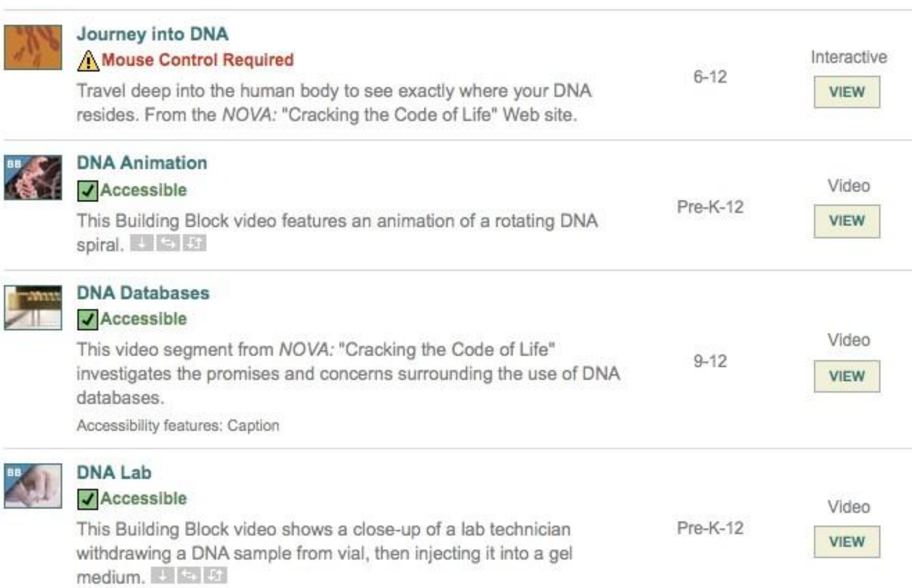
Metadata for Content

Metadata about the accessibility features of content helps users quickly find content that meets their access needs. As with the automating of interface transformations described above, content metadata or digital resource descriptions can support systems structured to turn on desired access features automatically. In a closed application such as a learning object repository, the content metadata can be used to discover content that is appropriate for the needs of the user. Based on metadata, content can be evaluated and ranked for its suitability in the device environment and ability to meet the expressed needs and then the most appropriate content can be selected for delivery by the system. For example, a learning resource that included an inaccessible video might be provided, but it could be accompanied with an alternate video that had been prioritized for selection based on information in its metadata.

The system would rank a video with the appropriate access requirements, the appropriate grade level, and other content descriptions higher than a video that failed to meet primary criteria around educational level and accessibility.

In Teachers' Domain, a free digital library of learning materials created by WGBH, accessibility metadata and preferences work together to provide customized information in search results as teachers plan lessons that include digital resources. In the example below, a user has indicated that they require keyboard accessibility in order to use interactive materials, so they are warned that one search result requires use of a mouse. The user has also indicated that they require captions to understand audio, and they can see from the search results that several videos are accessible to them—both one that has captions, and two that do not need captions because they have no soundtrack.

Figure 12: An example from Teachers' Domain that provides customized information about digital resources.



In the same way, publicly available online content could be made equally searchable if appropriate microdata (metadata that can be included in the content of a web page) are in place enabling resource from multiple sources to be compiled appropriately to meet declared user needs and preferences. Content matching requires metadata to determine what content works best (i.e. which video is captioned? Is there a text version of this speech?). Accessibility metadata is being proposed to Schema.org to improve search processes [http://www.a11ymetadata.org/]. Schema.org is a collaboration of major search engines to define microdata to allow users to filter search results for specific content areas. Accessibility microdata in Schema.org will support locating accessible resources within general search results. This microdata will need to be provided by publishers or curators of collections of metadata—a challenging task given the vast resources and content housed in online collections and sites. A future solution would be that all content would offer multiple accessibility features and be designed inclusively thus limiting the need for accessibility metadata.

Matching Preferences to Tool Features

As part of Cloud4all/GPII, there are prototypes in user testing to create a system for matching users to AT tools by using metadata that shows which preferences each tool is capable of supporting. The “Shopping Aid” will “use the preferences to list available access features and products that may be of use to” the user [GPII, 2011 http://gpii.net/programs/extended-usability-wizard].

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