Framing the Universal Design of Information and Communication Technology: An Interdisciplinary Model for Research and Practice

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Abstract. Research has yet to provide an interdisciplinary framework for examining ICT accessibility as it relates to Universal Design. This article assesses the conceptualizations and interdisciplinarity of ICT accessibility and Universal Design research. This article uses a grounded theory approach to pose a *multilevel framework for Universal Design*. The *macro* level, consists of scholarship that examines the context of Universal Design, and is typified by legal and sociological studies that investigate social norms and environments. The *meso* level, which consists of scholarship that examines activity in Universal Design as an approach to removing barriers for use and participation. The *meso* level is typified by studies of computer science and engineering that investigate the use of technology as a mechanism of participation. The *micro* level consists of scholarship that examines individuals and groups in Universal Design as an approach to understanding human characteristics. The *micro* level is typified by studies of human factors and psychology. This article argues that the *multilevel framework for Universal Design* may help remove the artificial separation between disciplines concerned with ICT accessibility and promote more fruitful research and development.

Keywords. Universal Design, ICT accessibility, multilevel framework for Universal Design, universal access, usability, design for all

1. Introduction

Since the 1990s, researchers in a variety of disciplines[2] have examined information and communication technology (ICT) accessibility and related concepts[3]. From the early 2000's, research has attempted to synthesize the variety of concepts used in reference to ICT accessibility and Universal Design with the aim to pose a single unified definition for use in research and practice [1-4].

However, research has yet to provide an interdisciplinary framework for examining ICT accessibility as it relates to Universal Design. This article aims to

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[2] The different disciplines that have examined ICT accessibility include law, political science, anthropology, sociology, psychology, neuroscience, rehabilitative medicine and computer science.

[3] ICT accessibility relates to concepts such as Universal Design, universal usability, accessibility, universal access and design for all.

extend previous research by providing an interdisciplinary analytic model for conducting research and development in accessible and universally designed technology. This article asks, "How can interdisciplinary perspectives be combined to promote research and development in ICT that is usable by the widest possible population?" This article presents research in progress, which uses a grounded theory approach to pose a *multilevel framework for Universal Design*.

The *multilevel framework for Universal Design* consists of three levels that vary based on the area of investigation. The widest scope of inquiry, which this article presents as the *macro* level, consists of scholarship that examines the context of Universal Design. The *macro* level is typified by legal and sociological studies that investigate the context for Universal Design in relation to social norms and environments. The narrowest scope of inquiry, which this article presents as the *micro* level, consists of scholarship that examines individuals and groups in Universal Design as an approach to understanding human characteristics. The *micro* level is typified by studies of human factors and psychology. In an intermediate scope of inquiry, this article presents the *meso* level, which consists of scholarship that examines activity in Universal Design as an approach to removing barriers for use and participation. The *meso* level is typified by studies of computer science and engineering that investigate the use of technology as a mechanism of participation. While this article presents the different levels as distinct, in practice, they represent a spectrum of interdisciplinary ideas and approaches. Thus, this article argues that the *multilevel framework for Universal Design* may help remove the artificial separation between disciplines concerned with ICT accessibility and promote more fruitful research and development.

This article begins by reviewing previous research on ICT accessibility. Then it presents the grounded theory methods used to generate the *multilevel framework for Universal Design*. This article proceeds by analysing research that has assimilated and synthesized the various approaches used to investigate ICT accessibility. It then examines efforts by academic publishers to promote interdisciplinary research in ICT accessibility and Universal Design. This article continues by presenting the *multilevel framework for Universal Design*, and it concludes by providing further recommendations for research and practice.

2. Research on ICT Accessibility

Research on ICT accessibility has spanned a range of disciplinary approaches. While this article presents legal, organizational and technological perspectives on ICT accessibility as analytically distinct, in practice, the different perspectives overlap.

2.1. Legal Perspectives on ICT Accessibility

From a legal perspective, ICT accessibility research has focused on the interpretations of laws that promote ICT accessibility [5-15]. Research has categorized ICT accessibility laws as regulative or redistributive [16]. Regulative laws refer to legal mandates for service providers to ensure ICT accessibility in practice. Research that examines regulative ICT accessibility laws typically investigates the legal basis for ICT accessibility and the legal disputes that have emerged over interpretations of antidiscrimination law [5, 6, 8-10, 12]. For example, research has examined mandates

for ICT accessibility based on the interpretation of disability antidiscrimination legislation [8, 12, 17].

In contrast, redistributive laws refer to legislation that mandates government provision of services "in cash and in kind" with the aim of promoting ICT accessibility [16]. While not as extensive as research on regulative ICT accessibility laws, research that examines redistributive ICT accessibility laws has investigated public sector programs and sources of funding that promote the research, development and production of accessible ICT [13-15]. For example, Ferri [13] examines the use of European Union (EU) funding to promote "the availability and choice of accessible technology" in the EU. In addition, Ferri and Giannoumis [15] examine EU programs that aim to provide access to culture and analyses the potential uses of EU copyright law for promoting and ensuring the accessibility of cultural products provided using ICT.

While research on regulative and redistributive ICT accessibility laws has primarily focused on legal interpretation, research has also bridged legal and organizational perspectives [7, 10]. Research that examines ICT accessibility from both legal and organizational perspectives has investigated the legal interpretation and the organizational effects of ICT accessibility laws. For example, Wall and Sarver [7] examine legislation in the United States (US) that aims to eliminate disability discrimination and argue that higher education institutions have an obligation to ensure that online course material and learning environments are accessible for students with disabilities. Similarly, Wentz, Jaeger [10] examine the role of disability rights laws in reinforcing inequality. The authors provide recommendations aimed at ensuring that organizations create "born-accessible" technology as opposed to retrofitting accessibility.

The literature reviewed in this section suggests that, from a legal perspective, ICT accessibility research has focused on the interpretations of disability antidiscrimination legislation and, to a lesser extent, the obligations of service providers to ensure accessibility in practice.

2.2. Organizational Perspectives on ICT Accessibility

From an organizational perspective, ICT accessibility research has focused on the practices of public and private sector organizations [18-25]. While the focus of research on organizational practices vary, this article suggests that, from an organizational perspective, ICT accessibility research focuses on organizational processes. For example, in a case study of Microsoft, Sandler and Blanck [18] examine the influence of organizational culture on processes for promoting workforce diversity and product and service usability. In another study on organizational processes, Velleman, Nahuis [20]examine the processes involved in public sector adoption and implementation of accessibility standards.

Research has further examined organizational practices in relation to other public and private sector actors [26-28]. Pathakji [27] argues for a "procedure-based strategy" for promoting ICT accessibility. The author suggests that codes of conduct, which aim to influence organizational practices, provide a useful basis for promoting accessibility by enabling accessibility advocates to hold enterprises accountable. Giannoumis [26] similarly argues that audit and certification services offered by web accessibility advocates can act as a mechanism for promoting compliance with web accessibility standards. Finally, Stienstra, Watzke [28] examines the relationship between private

enterprises and persons with disabilities as consumers and suggests that persons with disabilities, as early adopters of ICT and vocal proponents of accessible ICT, can add value to product development and marketing processes.

The literature reviewed in this section suggests that, from an organizational perspective, ICT accessibility research has focused on organizational processes and the influence of persons with disabilities and web accessibility advocates on the practices of private enterprises.

2.3. Technological Perspectives on ICT Accessibility

From a technological perspective, ICT accessibility research has focused on testing the accessibility and usability of different technologies [29-32]. Much of ICT accessibility research has focused on the accessibility of web content in specific sectors, such as public libraries [33-38], education [39-44], transport [45], private enterprise [46], financial services [47] and health services [48]. Research has also assessed web accessibility in public services including federal and regional governments in low-, middle-, and high-income countries [49-58]. This research demonstrates that although public and private sector actors maintain a clear social responsibility for providing accessible information, government agencies and private enterprises have yet to remove barriers that persons with disabilities experience in accessing ICT.

In addition to research that focuses on testing ICT accessibility outcomes in various products and services, research has also focused on the methodology of ICT accessibility testing and evaluation [59-65]. Research on ICT accessibility methodology has focused on testing and evaluating ICT for particular groups of people based on individual characteristics (e.g., people who are dyslexic or blind) or the barriers that they experience (e.g., lack of alternative text for visual elements) [66-69]. In addition, methodological research on ICT accessibility may focus on specific technologies such as the web or mobile technologies [70-73].

The literature reviewed in this section suggests that, from a technological perspective, ICT accessibility research has focused on testing and evaluating the usability and accessibility of a variety of technologies for different groups of people and has investigated the methodological approaches used to research ICT accessibility.

3. Methods

This article uses a grounded theory approach to investigate the interdisciplinarity of research on Universal Design and ICT accessibility. According to Glaser and Strauss [74], grounded theory "is a way of arriving at theory suited to its supposed uses". The authors suggest that grounded theory aims "to be usable in practical applications … to give the practitioner understanding and some control of situations" and "to guide and provide a style for research on particular areas of behaviour".

Universal Design and ICT accessibility is subject to what Von Bertalanffy [75] describes as "equifinality". In essence, a variety of potential mechanisms can produce Universal Design and ICT accessibility related outcomes. As the review of ICT accessibility research in Section 2 suggested, factors such as national and international laws, organizational policies and practices as well as the design of ICT can influence accessibility outcomes. In addition, Universal Design and ICT accessibility research is subject to multifinality. Essentially, Universal Design and ICT accessibility represent

multiple possible outcomes. As Section 2 also suggested, ICT accessibility represents an array of technologies, functions and uses.

This article aims to use grounded theory to provide a practical model for Universal Design and ICT accessibility research and development by giving researchers and practitioners a tool to frame the application of Universal Design principles to ICT. Essentially, this article uses a grounded theory approach to provide a practical model to guide researchers in generating research aims and protocols and to give researchers some control over the wide scope and variability inherent in conceptualizations of Universal Design and ICT accessibility. In addition, this article uses grounded theory to provide a model for practitioners to create accessible ICT and to extend the scope of ICT development beyond design and engineering to include factors outside of human-computer interaction.

Glaser and Strauss [74] argue that "grounded theory is derived from data and then illustrated by characteristic examples of data". In this article, the *multilevel framework for Universal Design* is derived from documentary data gathered from publicly available sources including international law, organizational policies, a literature review of research conceptualizing ICT accessibility, and a sample of articles purposively selected as interdisciplinary research on ICT accessibility and Universal Design. This article uses this data to illustrate the *multilevel framework for Universal Design* and provide recommendations for future research and practice.

4. Conceptualizing ICT Accessibility and Universal Design

Research has attempted to integrate the variety of concepts used to examine ICT accessibility and Universal Design [1-4]. This research ranges from conceptualizations of accessibility that are limited to persons with disabilities to conceptualizations that relate to the broadest possible population.

Research by Ellcessor [76] examines the historical conceptualization and value of accessibility as a concept in research and practice. The author states that accessibility "remains both theoretically and practically useful precisely because it is so closely tied to disability, its cultures, and the technological, cultural, and political needs of people with disabilities". The author argues that the development of ICT has obscured concerns over accessibility for persons with disabilities and usability for everyone. According to the author, Universal Design focuses on disability while producing products that are "beneficial for a wider range of people". However, Ellcessor [76] contends that integrating accessibility within the broader conceptualization of Universal Design can "reaffirm social hierarchies in which what really matters are the benefits that Universal Design brings to other (normative, ablebodied) people". In addition, the author maintains that while Universal Design may reduce the social stigma associated with disability, it may also "deny the lived experiences of disability and the importance of a disability identity or culture for many people". Ultimately the author defines accessibility in relation to ICT as "the principles and processes by which digital media have been made to support devices, customizations, and options and thus to meet the needs of people with a range of disabilities". The conceptualization used by Ellcessor [76] narrowly focuses on *compatibility* with devices, customizations and options for persons with disabilities.

Research by Gossett, Gossett [4] also examines the intersection between accessibility and Universal Design in the construction of an office building for a

disability rights organization. The case study accounted for installation of ICT systems in the office building but focused more closely on the architectural design of the building. The authors argue that in practice, decision-making represented a trade-off between accessibility and Universal Design. The authors suggest that though accessibility and Universal Design may be compatible in principle, in practice, the outcomes of the two concepts may be incompatible. Instead of posing a new definition of accessibility or Universal Design, the authors model the two ideas as a continuum that intersects where a solution is both accessible and as universally designed as possible. In the model, the authors argue that accessibility varies from maximal to no access and Universal Design varies from "intuitive/integrated/flexible" to "specialized/segregated/technical". Research by Gossett, Gossett [4] suggests that in practice accessibility and Universal Design represent differing though overlapping outcomes. In comparison to Ellcessor [76], Gossett, Gossett [4] suggest a broader framework for examining accessibility and focuses, only to a limited extent, on *compatibility* in relation to "specialized/segregated/technical" characteristics of Universal Design.

Research by Iwarsson and Ståhl [3] have examined the definitions of accessibility and Universal Design in research on design for person-environment relationships. The authors refer to accessibility as the "encounter between the person's or group's functional capacity and the design and demands of the physical environment". The authors specify that accessibility "refers to compliance with official norms and standards". The authors also provide a definition of Universal Design as a process "that incorporates products … which, to the greatest extent possible, can be used by everyone". The authors argue that Universal Design focuses on "changing attitudes throughout society, emphasizing democracy, equity and citizenship". While the definition of accessibility posed by Iwarsson and Ståhl [3] focuses on *functional capacity, environmental* design and demands and *compliance* with norms and standards, the definition of Universal Design posed by Iwarsson and Ståhl [3] focuses on the *use* of products by *everyone.* Unlike Ellcessor [76] and Gossett, Gossett [4], Iwarsson and Ståhl [3] do not characterize accessibility or Universal Design in relation to *compatibility* with assistive technology.

Research by Persson, Åhman [1] has attempted to provide a single conceptualization for accessibility. The authors examine conceptualizations of accessibility used by government actors, standards organizations, businesses and professional organizations and argue that a unified definition for accessibility provides a basis for international cooperation and understanding. The authors define accessibility as "the extent to which products, systems, services, environments and facilities are able to be used by a population with the widest range of characteristics and capabilities (e.g. physical, cognitive, financial, social and cultural, etc.), to achieve a specified goal in a specified context". Persson, Åhman [1] conceptualize accessibility in relation to the *use* of ICT by the widest population – i.e., *everyone.* While Persson, Åhman [1] do not specify whether "products, systems, services, environments and facilities" must be compatible with assistive technologies, the authors discuss the use of assistive technologies in relation to universal access stating "[u]niversal access sometimes refers to … the possibilities for everyone to use the product or service even with assistive technologies, if necessary". Nonetheless, Persson, Åhman [1] chose a more succinct definition of accessibility. This article suggests that *compatibility* with assistive technologies is a necessary component of using ICT "to achieve a specified

goal in a specified context" and is therefore implicit in the definition of accessibility used by Persson, Åhman [1].

Petrie, Savva [2] defined web accessibility in relation to the user, their technology and their context of use and defined web accessibility as the design of websites to be usable in varying contexts "including mainstream and assistive technologies" by everyone, especially older and disabled persons. The CRPD provides a similar definition for Universal Design – the design of ICT to be usable by all people, "to the greatest extent possible, without the need for adaptation or specialized design". The CRPD includes the caveat that Universal Design "shall not exclude assistive devices for particular groups of persons with disabilities where this is needed". These two concepts, web accessibility as defined by Petrie, Savva [2] and Universal Design as defined by the CRPD, both encompass *everyone*, refer to the *usability* of ICT, and provide a caveat for designing ICT that ensures *compatibility with assistive technologies*.

This article adopts a narrow definition of ICT accessibility that complements the conceptualization adopted by Ellcessor [76] and argues that accessibility refers to the use of ICT by persons with disabilities. In referring to persons with disabilities, this article draws on the CRPD, which conceptualizes disability as "an evolving concept … that … results from the interaction between persons with impairments and attitudinal and environmental barriers that hinders their full and effective participation in society on an equal basis with others". Therefore, this article argues that accessibility focuses on the evolving relationship between persons with impairments and the barriers that hinder their full and effective use of ICT on an equal basis with others. This article contextualizes accessibility in relation to Universal Design. In acknowledgment of the lived experiences of disabilities and with appreciation for disability culture and the benefits of ICT for persons with disabilities, this article argues that Universal Design refers to the *use* of ICT by *everyone*, which necessitates both access to ICT for persons with disabilities and *compatibility* with assistive technology. In this way, this article seeks neither to subsume accessibility under Universal Design nor demarcate a clear division between the concepts and instead argues that Universal Design and accessibility are amorphous concepts that will continue to change with developments in research and changes in social norms.

5. Current State of Interdisciplinary Research on ICT Accessibility

International peer-reviewed journals specializing in topics related to ICT accessibility have recognized the interdisciplinary approaches to examining ICT accessibility. One such journal, *Universal Access in the Information Society*, describes itself as "an international, interdisciplinary refereed journal … addressing the accessibility, usability, and, ultimately, acceptability of … Technologies by anyone, anywhere, at anytime, and through any media and device" [77]. According to the journal, universal access refers to technologies "that are accessible and usable by all citizens, including the very young and the elderly and people with different types of disabilities" [77]. In accordance with its interdisciplinary focus, the journal additionally claims to publish research on technological and non-technological issues. The editorial board reflects the journal's interdisciplinary focus, and while the majority of the editorial board consists of computer scientists and engineers, the board additionally includes psychologists, social scientists and human factors researchers [78]. In 2015, the journal published 37 "long

paper" research articles, which included topics ranging from education, health and rehabilitation, methods and evaluation, standardization and a wide variety of topics within computer science, engineering and human factors research.

Another journal, which specializes in topics related to ICT accessibility, *Human Computer Interaction*, describes itself as "a multidisciplinary journal defining and reporting on fundamental research in human-computer interaction" [79]. According to the journal, human-computer interaction refers to "the theoretical, empirical, and methodological issues of interaction science and system design as it affects the user" [79]. The journal goes on to state that HCI research examines "the cognitive and social behaviour of system users and the organizational and social impacts of that usage" [79]. The journal argues that "usage can cover individuals, groups, communities, organizations, and networks, as well as societal impacts of system use" [79]. The editorial board reflects the journal's interdisciplinary focus, and consists mostly of computer scientists and psychologists [80]. However, the editorial board also includes human factors researchers and social and cognitive scientists. In 2015, the journal published 16 "Original Articles", which mostly included topics related to psychology and computer science. Nonetheless, the journal also published several articles that addressed topics such as health, methods and evaluation, gaming, communication and the development of practical guidelines.

6. Multilevel Framework for Universal Design

Research on the conceptualizations of ICT accessibility and current state of interdisciplinary research, provide a useful basis for posing a *multilevel framework for Universal Design*. While this section draws upon research and conceptualizations of ICT accessibility, it deliberately uses Universal Design out of recognition for groups of disenfranchised people that, due to the design of ICT, are not able to use ICT on an equal basis with others and who may or may not have an impairment [81]. In addition, this article adopts Universal Design in an effort to support the implementation of the CRPD, which obligates State Parties to "undertake or promote research and development of universally designed goods, services, equipment and facilities". As such, the *multilevel framework for Universal Design* aims to provide guidance for future research and development by encouraging interdisciplinary cooperation and the investigation of previously unexplored topics.

6.1. Macro Level: context

The *macro* level focuses on the context. In relation to conceptualizations of ICT accessibility and Universal Design, context relates to social norms and environments. Ellcessor [76] describes the context in relation to social norms or "principles and processes". Iwarsson and Ståhl [3], similarly describe context in relation to "compliance with norms and standards". The journal *Human Computer Interaction,* describes social norms in relation to research that examines "organizational and social implications" [79]. For example, research may examine context in relation to social norms by investigating the application of antidiscrimination legislation to organizational practices for ensuring Universal Design or accessible ICT. Environments may refer to both the setting as well as the barriers that relate to conceptualizations of ICT accessibility and Universal Design. Persson, Åhman [1], and

Petrie, Savva [2] refer to environments when they refer to different accessibility contexts. The journal *Universal Access in the Information Society* refers to environments in place and time. The journal describes universal access as "anywhere and anytime" [77]. For example, research may examine context in relation to environments by investigating organizational processes or environmental barriers, which promote or inhibit the development or use of accessible or universally designed ICT.

The CRPD refers to both social norms and environments when conceptualizing disability in relation to "attitudinal and environmental barriers". Thus, this article argues that framing Universal Design from a *macro* level emphasizes context and relates to social norms, which may include principles, processes, standards or attitudinal barriers, and environments, which may include temporal or physical settings and the barriers associated with those settings. Drawing on the disciplinary perspectives presented in section five, this article argues that research framing Universal Design from a *macro* level may benefit from perspectives rooted in social and political science, and legal, organizational and disability scholars.

6.2. Meso Level: activity

The *meso* level focuses on activity. In relation to conceptualizations of ICT accessibility and Universal Design, activity typically relates to use, but may also relate to broader aspects of participation in relation to use. For example, research may examine the use of technology in the classroom as a component of participation in education. In relation to conceptualizations of ICT accessibility and Universal Design, Iwarsson and Ståhl [3], Persson, Åhman [1], and Petrie, Savva [2] all refer to different objects of use. While Petrie, Savva [2] narrowly refers to use of websites, Iwarsson and Ståhl [3] refers to "use of products", and Persson, Åhman [1] refers to "use of products, systems, services, environments and facilities". To clarify, environments in the *meso* level refer only to the object of use, not to the broader context as referenced in the *macro* level. Persson, Åhman [1] further stipulates use in relation to achieving specific goals. The journal *Universal Access in the Information* Society refers to use "through any media or device" [79]. Petrie, Savva [2], Ellcessor [76] and Gossett, Gossett [4] refer to use in relation to compatibility with assistive technology.

The CRPD characterizes use in three ways. According to the CRPD, use must be "to the greatest extent possible", not require "adaptation or specialized design" and not exclude "assistive devices for particular groups of persons with disabilities where this is needed". Thus, this article argues that framing Universal Design from a *meso* level emphasizes activity and relates to the use of ICT, which may require compatibility with assistive technology. This article further argues that activity also involves what the CRPD describes as "participation on an equal basis with others". Drawing on the disciplinary perspectives presented in section five, this article argues that research framing Universal Design from a *meso* level may benefit from perspectives rooted in computer science and engineering.

6.3. Micro Level: individuals and groups

The *micro* level focuses on individuals and groups. In relation to conceptualizations of ICT accessibility and Universal Design, individuals and groups typically relate to human characteristics. While the CRPD and Iwarsson and Ståhl [3]

both refer to Universal Design in relation to everyone, Persson, Åhman [1] refers to accessibility in relation to the "widest range of characteristics and capabilities". Ellcessor [76] similarly describes accessibility in relation to persons with a range of disabilities. Iwarsson and Ståhl [3] describes accessibility in relation to a person's or group's functional capacities, which complements how the journal *Human Computer Interaction* refers to research that examines cognitive and social behaviour [79]. To clarify, behaviour in the *mico* level refers only to the functional capacities of individuals and groups and not the broader activities or uses referred to in the *meso* level. For example, research may examine the characteristics of persons with dyslexia by investigating the neurological activity or psychological experiences of a person or group of persons with dyslexia. Petrie, Savva [2] describe accessibility in relation to everyone, but then emphasize that accessibility applies especially to older and disabled persons. Rather than focusing on everyone, the journal *Universal Access in the Information Society* alludes to citizenship and specifies that universal access includes the young and old and persons with different disabilities [77].

Thus, this article argues that framing Universal Design from a *micro* level emphasizes individual and group characteristics, which may refer to function, capability, disability, or age. Drawing on the disciplinary perspectives presented in section five, this article argues that research framing Universal Design from a *micro* level may benefit from disciplinary perspectives rooted in psychology and human factors.

7. Conclusion

This article asked, "How can interdisciplinary perspectives be combined to promote research and development in ICT that is usable by the widest possible population?" This article has argued that interdisciplinary perspectives can be analytically combined using the *multilevel framework for Universal Design*.

This article poses a *multilevel framework for Universal Design,* which consists of three levels. The *macro* level focuses on the context and relates to social norms and environments. Examining Universal Design from a *macro* level may benefit from perspectives rooted in social and political science, and legal, organizational and disability scholars. The *meso* level relates to activity and focuses on use and participation. Examining Universal Design from a *meso* level may benefit from perspectives rooted in computer science and engineering. The *micro* level relates to individuals and groups and focuses on human characteristics. Examining Universal Design from a *macro* level may benefit from perspectives rooted in psychology and human factors.

This article argues that the *multilevel framework for Universal Design* provides a useful basis for conducting interdisciplinary research and development of accessible ICT and may support State Parties obligations under the CRPD to conduct research and development of universally designed goods, services, equipment and facilities. In addition, the *multilevel framework for Universal Design* provides a useful basis for examining topics within ICT accessibility that are still nascent. For example, ICT accessibility research has yet to examine fully the barriers to using ICT that are experienced by persons subject to multiple forms of discrimination. The *multilevel framework for Universal Design* provides a useful and interdisciplinary approach for

examining the social norms, activities and individual or group characteristics of persons that experience multiple forms of discrimination in using ICT.

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