

INCLUSIVE DESIGN FOR DIGITAL LEARNING: THE UDL FRAMEWORK

Assoc. Prof. Mariya Monova-Zheleva
Burgas Free University, mariaj@bfu.bg

Assoc. Prof. Yanislav Zhelev
Burgas Free University, jelev@bfu.bg

***Abstract.** The prevalence of technology in all aspects of society, education, and work presents new opportunities to overcome challenges associated with vulnerable participants' inclusion. The proliferation of digital technologies in education, encompassing diverse technology-enhanced learning implementations like blended learning, online courses, simulations, virtual classrooms, and mobile learning, necessitates a paradigm shift based on the effective application of inclusive design principles and frameworks towards ensuring the learning environments, teaching materials, and educational services that are universally usable by all students, to the maximum extent possible. Researchers and experts in education and instructional design discuss and experiment with many proactive methodologies and instructional design approaches that prioritize the needs of a heterogeneous user base in digital learning environment development. The current paper presents some results and findings of a study that investigates globally recognized methodologies, principles, and frameworks for the design and development of inclusive digital learning environments carried out within the Erasmus+ project „Inclusive Digital Learning (Dig-2-Inc, 2022-1-FI01-KA220-HED-000090147).*

***Keywords:** Inclusive Digital Education, Universal Design, Assistive Technologies, Web Content Accessibility Guidelines, Universal Design for Learning.*

Introduction

The presence of heterogeneous learners requires the implementation of inclusive instructional design practices that address the spectrum of learning styles and requirements.

The concept of inclusive education, as advocated by UNESCO (UNESCO, 2005), necessitates providing individualized support catering to the specific needs of each learner throughout their educational journey. The United Nations 2030 Agenda for Sustainable Development, emphasizes Sustainable Development Goals and offers a promising framework focused on establishing a new paradigm for inclusive and sustainable development, aiming to guarantee freedom from poverty and fear for all individuals, irrespective of background. The principle of „Leave No One Behind“ serves as a core tenet within the United Nations Sustainable Development Cooperation Framework (UN Sustainable DG, 2016). Respecting universal design (UD) principles, fostering non-discrimination, ensuring information accessibility, and promoting gender equality in education delivery are all crucial for achieving inclusivity (UNESCO, 2016).

The Global Forum of the OECD Future of Education and Skills 2030 also underscores the necessity for effective implementation strategies based on inclusive design principles that guarantee appropriate access for diverse student populations (Gottschalk, OECD, & Weise, 2023).



From a European standpoint, inclusivity, equity, and diversity are key priorities in the European Digital Education Action Plan 2021-2027 (European Commission/EACEA/Eurydice, 2022), (European Commission, 2020).

Researchers and experts in education and instructional design discuss and experiment with many proactive methodologies and instructional design approaches that prioritize the needs of a heterogeneous user base in digital learning environment development. These methodologies encompass inclusive design (Inclusive Design Research Centre, n.d.), accessible design (Centre for Excellence in Universal Design, n.d.) and universal design (Interaction Design Foundation, n.d.) (UNESCO, 2005), (Center for Applied Special Technology, n.d.).

The current paper presents some results and findings of a study that investigates globally recognized methodologies, principles, and frameworks for the design and development of inclusive digital learning environments carried out within the Erasmus+ project “Inclusive Digital Learning (Dig-2-Inc, 2022-1-FI01-KA220-HED-000090147).

Universal Design Methodology

Universal Design (UD) stands out as a leading approach for inclusive design, offering a comprehensive set of principles that guide efficient and effective product creation for all users from start to finish. The seminal definition of universal design (UD) emerged in 1997, established by a collaborative effort at the Center for Universal Design at North Carolina State University (Vinney, 2021). This working group, comprised of architects, product designers, engineers, and environmental design researchers, defined UD as: „The design of products and environments to be usable by all people, to the greatest extent possible, without the need for adaptation or specialized design.“ UD has its origins in architecture and industrial design but has recently expanded to include digital products and services and this foundational definition remains the cornerstone of UD principles today (Centre for Excellence in Universal Design, n.d.).

Through the lens of UD, the creation of teaching and learning experiences can be re-conceptualized as the systematic development of products and environments that inherently promote usability for a broad spectrum of learners (inclusiveness), with minimal reliance on adaptations or design interventions (accessibility).

The Inclusive Digital Education report by the European Agency for Special Needs and Inclusive Education (2022) emphasizes the ultimate vision for inclusive education systems. This vision entails ensuring that all learners, regardless of age, access meaningful and high-quality educational opportunities within their local communities. This necessitates a systemic transformation across all levels of the education system. Furthermore, it requires the application of a user-centred design approach that embraces UD principles and deployment of assistive technologies, when universally designed technology is insufficient, to prevent exclusion in digital education by avoiding drawbacks like poor usability, high costs, or lack of IT support (European Agency for Special Needs and Inclusive Education, 2022).

UD and the related concepts of inclusive design and accessibility (Ivey, 2022) are frequently intertwined, while they possess distinct nuances. Universal and inclusive designs encompass a broader aim: catering to the needs of a diverse user base, irrespective of their characteristics or identities.

Accessibility focuses on designing solutions addressed to the needs of individuals with physical and cognitive impairments. Accessibility is „an integral part of inclusive and universal design. While inclusive design and universal design both cater to the widest range

of users, the universal design strives for a single solution to cater to everyone, while inclusive design tries to achieve the goal through multiple adaptations” (Interaction Design Foundation, 2016). Despite some overlap, universal and inclusive design are not interchangeable terms. UD strives to achieve a single, optimal design solution that accommodates the widest range of users possible. This inherently acknowledges that some degree of exclusion may be unavoidable. In contrast to UD, inclusive design aims to develop solutions that prevent the exclusion or marginalization of any user group. This may necessitate the development of multiple design solutions to meet different user needs.

UD aims to exceed minimum standards to guide design that is fit for purpose and which can be used by the broadest range of people. UD offers a well-defined set of principles that guide the design process towards achieving inclusivity.

Inclusive design, on the other hand, emphasizes a user-centred approach, advocating for the direct participation of a diverse range of individuals within the design process itself.

The seven UD were formulated by a team of architects, product designers, engineers, and environmental design researchers under the leadership of the late Ronald Mace in 1997. These principles serve as a comprehensive framework for designing inclusive environments, products, and communication systems and are efficiently integrated into the teaching and learning paradigms.

The seven principles of UD are as follows (Centre for Excellence in Universal Design):

1: Equitable Use - The design is useful and marketable to people with diverse abilities.

The design should be universally usable, fostering inclusivity for all individuals irrespective of their background or capabilities. Crucially, this principle necessitates the absence of exclusion or marginalization of any user group. Furthermore, the design should prioritize the user's sense of privacy, security, and safety during interaction.

2: Flexibility in Use - The design accommodates a variety of individual preferences and abilities.

Users should be able to go at their own pace and accurately complete tasks no matter what method they prefer to use.

3: Simple and Intuitive Use – The design is easy to use and understand, regardless of the user's experience, knowledge, language skills, or current concentration level.

Designs shouldn't be needlessly complex, instead, they should work with users' expectations while also providing messaging at every stage of a task to ensure a user knows they are on the right track.

4: Perceptible Information – The design communicates necessary information effectively to the user, regardless of ambient conditions or the user's sensory abilities.

Important information should be presented in multiple ways (information redundancy) visual and textual. It should be ensured that the designs work with devices used by people with physical limitations (assistive technology compatibility).

5: Tolerance for Error – The hazards and the adverse consequences of accidental or unintended actions should be minimized.

Designs should prevent errors whenever possible. When some errors happen, users should easily recover without losing progress.

6: Low Physical Effort – The design can be used efficiently and comfortably, with minimum effort.

The designs should be intuitive and effortless to use, to support efficient interaction, and minimize repetitive actions and sustained physical effort.



7: Size and Space for Approach and Use - Appropriate size and space are provided for approach, reach, manipulation, and use regardless of the user's body size, posture, or mobility.

Design elements should be positioned and sized in a way that allows all users to comfortably interact with them (touch, click or manipulate).

The Centre for Excellence in Universal Design (CEUD) leverages a framework (model) based on the human ecological systems approach. This approach emphasizes the intricate interplay between individuals and their surrounding environments across various levels (Centre for Excellence in Universal Design, n.d.):

- Macro level (European/National level) – policies, directives, legislation, awareness campaigns, ensuring the diffusion of UD and its adoption at national and regional levels, and standards such as the Customer Communications Toolkit (CEUD, 2023), ISO/IEC Guide 71:2014 (ISO/IEC, 2014) and EN 301 549, the European standard for digital accessibility (ETSI, 2021).
- Meso level (institutional level) – institutional practices, codes, monitoring/certification, policies and community involvement.
- Micro level (individual level) – recognition of user needs, resources/toolkits, environmental design and technologies including assistive technologies.

Web Content Accessibility Guidelines and the European Accessibility Act

The World Wide Web Consortium's (W3C) Web Accessibility Initiative (WAI) has spearheaded the development of the Web Content Accessibility Guidelines (WCAG) (W3C, 2023).

WCAG 2.2 (the current version issued in 2023) is an international standard composed of documents explaining how to make web content more accessible to people with special needs. It is developed in cooperation with individuals and organisations worldwide, to provide a single shared standard for eContent accessibility that meets the needs of individuals, organisations, and governments internationally.

The European Accessibility Act is a directive of the European Union (EU) which took effect in April 2019. This directive aims to improve the trade between members of the EU for accessible products and services, by removing country-specific rules. The European policy of applying "Design for all" principles on digital technology led to the creation of the European Harmonized Accessibility Standards EN 301 549 which defines "Accessibility requirements suitable for public procurement of ICT products and services in Europe" (ETSI, 2021).

Within the educational technology domain, two key concepts are germane to ensuring inclusive access to learning materials: accessible technologies and assistive technologies.

According to the National Center on Accessible Educational Materials at the Center for Applied Special Technology, accessible technologies are "the hardware devices and software that provide learners with access to the content into accessible digital materials" (Center for Applied Special Technology, n.d.).

In contrast to universally designed accessible technologies, assistive technologies address specific barriers faced by learners with disabilities when interacting with educational materials. These tools are designed to bridge the gap between a learner's limitations and the demands of the educational content. Examples include text-to-speech software for learners with visual impairments, screen readers for those with blindness, and speech recognition software for individuals with motor skill limitations.

Specialized services exist to support learners with disabilities in navigating the landscape of assistive technologies. These services can involve needs' assessments, technology recommendations, training on using specific tools, and ongoing support to ensure optimal utilization of assistive technologies in the learning process.

A framework, grounded in four core principles, also known as POUR (Perceivable, Operable, Understandable, Robust), establishes a set of requirements for ensuring the accessibility of IT components.

The POUR principles are the foundation of the Web Content Accessibility Guidelines (WCAG) an international standard for making web content accessible.

Under each of the principles, there are guidelines and success criteria that help to address these principles for people with disabilities (W3C, 2023).

The next figure represents the POUR principles and their success criteria brief explanation.

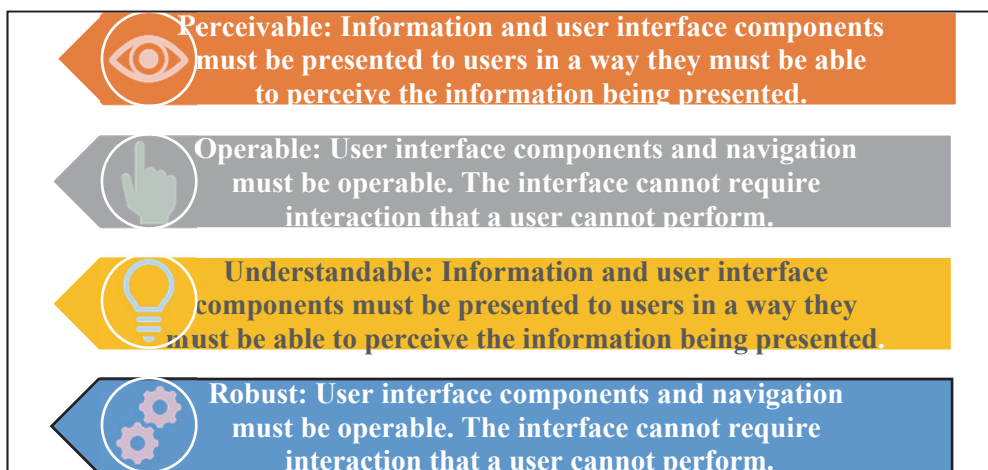


Figure 1. Web Content Accessibility Guidelines - Four Main Principles (POUR)
Source: <https://www.w3.org/TR/WCAG22/> (Our design)

The National Center on Accessible Educational Materials (AEM Center) at the Center for Applied Special Technology (CAST) provides a clear and concise explanation of the POUR principles from the education perspective as well as concrete guidelines for practical application (AEM Center at CAST, n.d.):

- **Perceivable content:** All learners can see and hear the information presented. To ensure perceivable content, it's essential to present this content in various formats. This way the learners will be empowered to personalize their learning experience by adjusting the information presentation to their specific needs and preferences. The process of the perceivable content provision encompasses the following steps: adding the text descriptions to images; including closed captions and transcripts; providing sufficient color contrast and not using color alone; and creating readable and legible texts.
- **Operable content:** All learners can navigate the information independently using their preferred tools. Operable content requires different navigation options to be provided so the users to be able to navigate and interact with the content: with a mouse, a keyboard or even voice commands. The steps to make the content



operable are as follows: provision of a clear structure with headings; creating descriptive links; check for keyboard accessibility; provision of sufficient time; and avoiding content that flashes.

- Understandable content supports the learners' understanding through a consistent and predictable design. The understandable content is intuitive and behaves predictably for learners. This ensures that the learners will focus mainly on understanding the information rather than working around design barriers. The steps to make the content understandable are as follows: provision of clear directions; consistency, in both the structure and formatting of the information; using plain language appropriate for the reading level of the audience; identifying the language - help screen readers select the correct voice and pronunciation rules.
- Robust content works for the learners on a range of current and future technologies, including assistive technologies. Robust content works on different web browsers and devices (including tablets and smartphones). The steps to make the content robust are as follows: provision of descriptive metadata; accessibility check performing; testing the accessibility with people.

The principles of Universal Design extend their applicability beyond physical environments and products to encompass the realm of teaching and learning. This framework can be applied to learning environments, resources, and instructional methods (Rao, *Inclusive Instructional Design: Applying UDL to Online Learning*, 2021).

Universal Design for Learning (UDL) was developed in the 1990s and early 2000s by Anne Meyer, David Rose, and their colleagues at the Center for Applied Special Technology (CAST based on the new insights from the learning sciences and creative uses of digital technologies).

UDL is a framework for developing a curriculum that is more accessible for all. UDL is also intended to guide the development of inclusive learning environments based on the three core principles that aim to ensure that diverse learners, with varying abilities in sight, hearing, speech, movement, literacy, language comprehension, attention, organization, engagement, and memory, can achieve the defined learning objectives (Center for Applied Special Technology, n.d.). The UDL framework, used as part of an instructional design process, provides a structure for proactive lesson design, integrating inclusive strategies and options that can support all learners in the classroom (Meyer, Rose, & Gordon, 2014) at various educational levels and for varied instructional purposes (Rao, Ok, & Bryant, 2014) (Ok & Rao, 2019).

UDL is achieved through the implementation of flexible curricular materials and activities that cater to the individual strengths and needs of a heterogeneous learner population. Universal Design for Learning acknowledges learner variability as the standard. Recognizing the spectrum of abilities, strengths, experiences, and preferences within any learning group (Meyer, Rose, & Gordon, 2014), UDL provides a framework for proactive support. This instructional design approach allows educators to integrate flexible options from the outset, ensuring inclusivity for a broader range of learners.

UDL's fundamental ideas are related to addressing the following three key issues (Rao, *Inclusive Instructional Design: Applying UDL to Online Learning*, 2021): the learners' variability; reducing barriers in curriculum and instruction, and developing expert learners who are purposeful and motivated, resourceful and knowledgeable, strategic and goal-directed.

The Center for Applied Special Technology (CAST) created a set of three principles with roots in cognitive neuroscience to underpin practices and curricula for teaching and learning (Burgstahler, 2021). UDL's core principles are as follows:

- Multiple means of engagement. For purposeful, motivated learners, stimulate interest and motivation for learning.
- Multiple means of representation. For resourceful, knowledgeable learners, present information and content in different ways.
- Multiple means of action and expression. For strategic, goal-directed learners, differentiate how students can express what they know.

The Universal Design for Learning (UDL) Guidelines outline a range of considerations for designing flexible learning experiences based on the utilization of digital educational resources, interactive content and media. The guidelines are structured in the three main categories related to the UDL core principles: Representation, Action and Expression, and Engagement.

- Engagement: Affective factors play a critical role in learning, with learners exhibiting significant variation in their engagement and motivation. Multiple sources contribute to this individual variability, including neurological factors, cultural background, perceived relevance, subjective experiences, and prior knowledge. For instance, some learners thrive on spontaneity and novelty, while others find such elements unsettling and prefer structured routines. Similarly, some learners favour independent work, while others benefit from collaboration. Consequently, no single motivational approach will be universally effective. Therefore, providing a range of engagement options is essential.
- Representation: Individual learner variability extends to the perception and comprehension of presented information. Effective learning and knowledge transfer hinge on the provision of multiple representations. These diverse formats, encompassing various symbolic systems and sensory modalities, facilitate the creation of connections within and between concepts. In essence, no single representational mode is universally optimal. Therefore, ensuring a range of representational options is critical.
- Action and Expression: Learners exhibit significant variability in navigating learning environments and demonstrating acquired knowledge. Furthermore, strategic planning, practice, and organizational skills are crucial for effective action and expression, and these areas represent another dimension of learner diversity. Consequently, no single mode of action and expression will be universally optimal. Therefore, providing a range of options for action and expression is essential.

The UDL Design Cycle (Rao & Meo, 2016) integrates the core components of commonly used instructional design models and processes, such as ADDIE (InstructionalDesign.org) and Backwards Design (Gonzales, 2020).

Like the ADDIE process, the UDL Design Cycle begins with a learner analysis and bases instructional design decisions on what is known about the learners. The UDL cycle encompasses six steps presented in the next figure (Rao, Inclusive Instructional Design: Applying UDL to Online Learning, 2021).

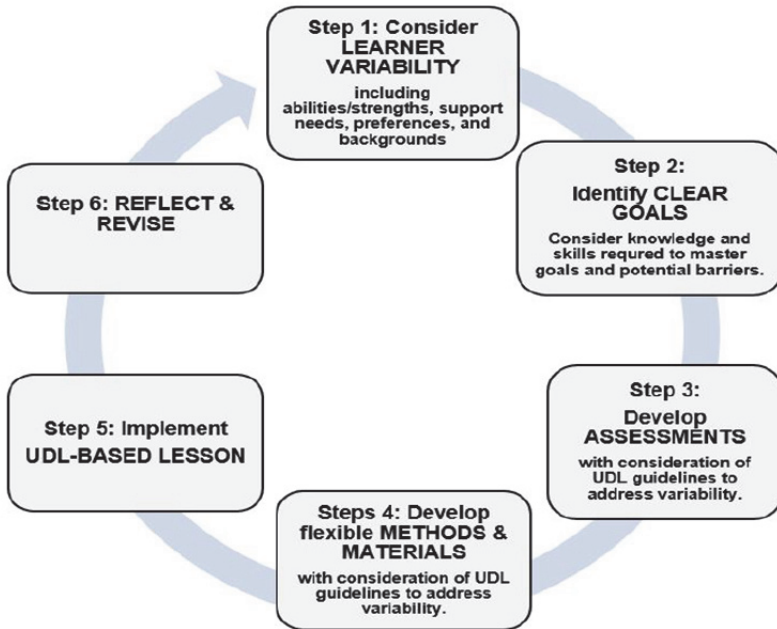


Figure 2. UDL Design Cycle (Source: https://edtechbooks.org/jaid_10_1/preparing_teachers_f)

The UDL principles and guidelines possess broad applicability within the educational sphere. They can be effectively utilized across various educational endeavours, encompassing curriculum development, lesson planning, and the design and subsequent reporting of interventions grounded in UDL principles.

Conclusion

From the perspective of the digital education paradigm, it is clear that technology offers great potential, but it can also introduce challenges in terms of accessibility for individuals of low socio-economic status, including those with disabilities. Despite increased access to information, current technologies may not allow all users to interact equally with the learning environment and resources.

UDL provides a framework for designing learning solutions focused on all learners' inclusion and providing opportunities for them to learn effectively. The WCAG, developed by the World Wide Web Consortium, provide a critical framework for ensuring UDL principles. These guidelines are aimed at both web developers and creators of learning content and educational environments to ensure accessibility to digital content, tools, and services for a diverse range of users, including vulnerable learners.

Through UDL principles application adhering to WCAG, technology could be leveraged to implement instructional design practices that proactively mitigate barriers and integrate supportive elements within the digital learning environment, fostering a more inclusive learning experience for all students and empowering them to achieve their full potential.

References:

1. AEM Center at CAST. (n.d.). Designing for Accessibility. Retrieved from <https://aem.cast.org/create/designing-accessibility-pour>
2. Burgstahler, S. (2021). Universal Design: Process, Principles, and Applications. Retrieved from Disabilities, Opportunities, Internetworking, and Technology: <https://www.washington.edu/doi/universal-design-process-principles-and-applications>
3. Center for Applied Special Technology. (n.d.). Learn About Universal Design for Learning (UDL). Retrieved from <http://bookbuilder.cast.org/learn.php>
4. Center for Applied Special Technology. (n.d.). What is Accessibility? Retrieved from <https://aem.cast.org/get-started/defining-accessibility>
5. Centre for Excellence in Universal Design. (n.d.). Definition and Overview of Universal Design (UD). Retrieved from Centre for Excellence in Universal Design: <https://universaldesign.ie/>
6. Centre for Excellence in Universal Design. (n.d.). The 7 Principles. Retrieved from Centre for Excellence in Universal Design: <https://universaldesign.ie/about-universal-design/the-7-principles>
7. Centre for Excellence in Universal Design. (n.d.). Universal Design: Definition and overview. Retrieved from <https://universaldesign.ie/what-is-universal-design/definition-and-overview/>
8. CEUD. (2023). Retrieved from https://universaldesign.ie/uploads/publications/Custom-Communications-Toolkit-2023-PDF_Final.pdf
9. ENQA. (2022, February 2). Policy brief: European strategy for universities. Retrieved from <https://www.enqa.eu/news/policy-brief-european-strategy-for-universities/>
10. ETSI. (2021). Accessibility requirements for ICT products and services. Retrieved from https://www.etsi.org/deliver/etsi_en/301500_301599/301549/03.02.01_60/en_301549v030201p.pdf
11. European Agency for Special Needs and Inclusive Education. (2022). Inclusive Digital Education. Policy Brief. Retrieved from https://www.european-agency.org/sites/default/files/Inclusive_Digital_Education_Policy_Brief_EN.pdf
12. European Commission. (2020). Digital Education Action Plan 2021-2027 Resetting education and training for the digital age. Retrieved from <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52020DC0624>
13. European Commission. (2022). European Commission Communication on a European strategy for universities. Retrieved from <https://education.ec.europa.eu/sites/default/files/2022-01/communication-european-strategy-for-universities.pdf>
14. European Commission/EACEA/Eurydice. (2022). Towards equity and inclusion in higher education in Europe. Eurydice report. Luxembourg: Publications Office of the European Union.
15. Gonzales, J. (2020). Backward Design: The Basics. Retrieved from Cult of Pedagogy: <https://www.cultofpedagogy.com/backward-design-basics/>
16. Gottschalk, F., OECD, & Weise, C. (2023). Digital equity and inclusion in education: An overview of practice and policy in OECD countries. Retrieved from <https://www.oecd.org/publications/digital-equity-and-inclusion-in-education-7cb15030-en.htm>



17. Inclusive Design Research Centre. (n.d.). What is inclusive design. Retrieved from <https://legacy.idrc.ocadu.ca/resources/idrc-online/49-articles-and-papers/443-whatisinclusivedesign>
18. InstructionalDesign.org. (n.d.). ADDIE. Retrieved from Instructional Design Models: <https://www.instructionaldesign.org/models/addie/>
19. Interaction Design Foundation. (2016). What is Inclusive Design? Retrieved from <https://www.interaction-design.org/literature/topics/inclusive-design>
20. Interaction Design Foundation. (n.d.). Accessibility. Retrieved from <https://www.interaction-design.org/literature/topics/accessibility>
21. ISO/IEC. (2014). Guide for addressing accessibility in standards. Retrieved from <https://www.iec.ch/webstore/freepubs/isoiecguide71%7Bed2.0%7Den.pdf>
22. Ivey, S. (2022). The Importance of Usability and Accessibility in Design. Retrieved from CF BLOG: <https://careerfoundry.com/en/blog/ux-design/the-importance-of-usability-and-accessibility-in-design/>
23. Meyer, A., Rose, D., & Gordon, D. (2014). Universal Design for Learning: Theory and practice. . CAST Professional Publishing.
24. National AEM Center at CAST. (2022). Protocol for Creating Accessible OER. Retrieved from <https://aem.cast.org/binaries/content/assets/common/publications/aem/protocol-creating-accessible-oer-allly.pdf>
25. Ok, M., & Rao, K. (2019). Technology tools for the inclusive classroom: Using Google Chrome to support all learners. *Journal of Special Education Technology*, 34(3), pp. 204-211. doi:<https://doi.org/10.1177/0162643419841546>
26. Rao, K. (2021). Inclusive Instructional Design: Applying UDL to Online Learning. Retrieved from *The Journal of Applied Instructional Design*: DOI:10.59668/223.3753
27. Rao, K., Ok, M., & Bryant, B. (2014). A review of research on universal design educational models. *Remedial and Special Education*, 35(3), pp. 153-166. doi:<https://doi.org/10.1177/0741932513518980>
28. UN Sustainable DG. (2016). Retrieved from <https://unsdg.un.org/2030-agenda/universal-values/leave-no-one-behind>
29. UNESCO. (2005). Guidelines for inclusion: ensuring access to education for all. Retrieved from <https://unesdoc.unesco.org/ark:/48223/pf0000140224>
30. UNESCO. (2016). Learning for All: guidelines on the inclusion of learners with disabilities in open and distance learning. Retrieved from <https://unesdoc.unesco.org/ark:/48223/pf0000244355>
31. United Nations. (n.d.). Retrieved from <https://www.un.org/sustainabledevelopment/>
32. Vinney, C. (2021, August 05). Inclusive Design vs. Universal Design: What's the Difference? Retrieved from CF BLOG: <https://careerfoundry.com/en/blog/ux-design/universal-vs-inclusive-design/>
33. W3C. (2023). Web Content Accessibility Guidelines (WCAG) 2.2. Retrieved from <https://www.w3.org/TR/WCAG22/#glossary>