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UNIVERSAL DESIGN IN THE ORGANIZATION OF WORKPLACES – A LITERATURE REVIEW

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Purpose: This paper aims to identify and evaluate the application of universal design (UD) principles in workplace organisation through a systematic literature review. The research aims to: 1. Analyse the dimensions of accessibility, including physical, digital, information, communication, social and sensory aspects in the workplace. 2. Identify specific applications of UD in organising accessible and inclusive workplaces.3. Identify the benefits, challenges and best practices associated with implementing UD principles to increase inclusion and productivity in the workplace.
Design/methodology/approach: This paper uses a systematic literature review methodolog, analysing articles from databases such as Scopus, Web of Science and PubMed.
Findings: The literature review reveals several critical findings: 1. Applications of UD: Ergonomic design, assistive technologies, etc. were highlighted as key applications of UD in workplace design. 2. Benefits: Increased integration, improved employee satisfaction and retention, increased productivity and innovative workplace solutions**.** 3. Challenges: Financial constraints, limited awareness and lack of training, contextual differences and insufficiently researched sensory accessibility needs. 4. Best practices: Early integration of UD principles, stakeholder engagement, adapted strategies and adoption of new technologies to enhance workplace accessibility.
Research limitations/implications: Lack of sectoral research on specific industry needs. Limited research on the lasting impact of UD in the work environment. Under-representation of description of sensory accessibility in the literature.
Practical implications: The research findings suggest practical recommendations for organisations:
1. Invest in training programmes to raise awareness and build expertise in UD principles.
2. Incorporate UD into the early stages of workplace design to avoid costly retrofitting.
3. Use assistive technologies and flexible infrastructure to meet the diverse needs of the workforce.
Social implications: This research highlights the importance of UD in supporting equitable and inclusive workplaces, by contributing to:
1. Improving the quality of life of employees, particularly those with disabilities or cognitive and sensory needs.
2. Positive socialetal attitudes towards diversity and inclusion.

3. Influence corporate social responsibility (CSR) and public policy to prioritise accessibility in the workplace.
Originality/value: This article provides a comprehensive synthesis of the literature on UD in workplace organisation, identifying under-researched dimensions such as sensory accessibility and the potential of new technologies.
Keywords: Universal design, workplace accessibility, inclusive design, ergonomic adaptations, assistive technologies.
Category of the paper: research paper.

1. Introduction

Universal Design (UD) is becoming one of the most important considerations in the design of public spaces, including the design of workplaces according to UD principles. UD has emerged as a transformative approach to creating inclusive environments that meet the diverse needs of individuals. UD is a concept with the principle of equality at its core; it aims to proactively design spaces, tools proactively, and processes that can be used by all, regardless of age, gender, ability, or background. In the context of the workplace, the integration of UD principles is becoming increasingly important as organisations strive to support inclusion by improving the wellbeing of their employees.Workplaces are dynamic environments shaped by technological advances, demographic changes and evolving organisational cultures. The application of UD in workplace organisation addresses different dimensions of accessibility, including physical, digital, cognitive, social and sensory accessibility. For example, the incorporation of assistive technologies and UD features, such as adjustable workstations and accessible digital tools, supports employees with disabilities and provides a more inclusive workforce (Mueller, 1998). Similarly, ergonomic adaptations and user-sensitive design frameworks are indicated to improve working conditions for ageing workers,and promote retention and well-being (Gonzalez, Morer, 2016). In addition to physical accessibility, cognitive and social accessibility have also received attention, particularly in supporting employee engagement with neurodiversity through collaborative design processes (Trotman, McGinley, 2018).

Despite the growing recognition of the benefits of UD, implementing UD in the context of the workplace remains a challenge. Organisations often face barriers such as financial constraints, lack of awareness among employers and employees and resistance to change (Corcuff et al., 2022). Furthermore, while the literature highlights advances in physical and digital accessibility, significant gaps remain in sensory accessibility and the integration of new technologies, such as artificial intelligence (AI) and the Internet of Things (IoT), to support dynamic workplace design (Begnum, Igeltjørn, 2024).

The authors focused on the thematic scope of Universal Design (UD), workplace accessibility, and diversity and inclusion in workplace design.

The aim of the article is to identify and evaluate the application of the universal design concept in the organisation of workplaces, based on the systematic literature review. Other aims of the article are:

G1. analysis of the literature on physical, digital, informational, communicative, social and sensory accessibility in the workplace,

G2. identification of applications of UD in the context of organising accessibility in the workplace,

G3. recognition of benefits, challenges, and best practices associated with the implementation of UD.

In order to achieve the research goal, the authors posed the following research questions:

R1. How is UD used in the context of workplace organization? In which areas? (e.g. social, digital, physical?)

R2. How does Universal Design influence the organisation of the workplace?

R3. What are the main benefits of implementing UD in the workplace?

R4. What are the main challenges and practices in implementing UD?

The analyses carried out in this article seek to:

1. Identify the relevance of Universal Design as an approach to creating inclusive work environments adapted to the diverse needs of users, including people with disabilities.
2. Identify key areas of research related to the implementation of UD in the workplace, including:
   - physical accessibility,
   - digital accessibility,
   - ergonomics and design.
3. Explore the benefits and challenges of implementing Universal Design in different organisational contexts.
4. Identify existing research gaps and make recommendations for future research and workplace design practitioners.
5. Facilitate the practical application of research findings by identifying best practices and strategies for implementing UD in professional settings.

2. Methods

In the research process, the authors used procedures typical of systematic literature reviews: selection of documents for review, the methodology for data identification, and the analysis of the results. The study was carried out in December 2024. The selection criteria for the literature were as follows:

- Timeframe of publications (from 1996 to 2024).
- Types of the literature sources: peer-reviewed scientific research.
- Management field.

The authors analysed articles using databases such as Scopus, Web of Science (WoS), and PubMed. The authors also supported their search methods with AI tools (ChatGPT 4.0, notebookLM), but these were only used for supportive searches.

Both Scopus and WoS were used as the most comprehensive databases for peer-reviewed literature (Baas et al., 2020; Baier-Fuentes et al., 2019; Mazur et al., 2018; Piwowar-Sulej, Iqbal, 2023) – both are comprehensive databases for systematic reviews. In the case of PubMed, its usefulness for analysing the impact of universal design on ergonomics and employee health was considered. The authors looked at the title, abstract, and keywords, using the following combination of words: universal design and management; universal design and workplace; physical, digital and social accessibility in the workplace; universal design in the workplace and best practices; universal design in the workplace and challenges. Authors used the following combinations of keywords:

- Universal Design, Workplace Organization, Accessibility.
- Inclusive Design, Physical Accessibility, Digital Accessibility, Social Inclusion.
- Universal Design, Ergonomics, Workplace Adaptation.
- Barrier-Free Design, Human-Centered Design, Inclusive Work Environments.
- Diversity and Inclusion, Organizational Performance, Workplace Productivity.
- Employee Engagement, Diverse Teams, Social Benefits of Universal Design.
- Implementation Challenges, Universal Design, Best Practices.
- Workplace Accessibility, Design Standards, Policy Guidelines.
- Universal Design Evaluation, Systematic Review, Research Trends.
- Litee Review, Comparative Analysis, UD Implementation Strategies.

The search strategies for each database are described below.

2.1. Scopus

(TITLE-ABS-KEY(universal AND design* AND workplace* AND organization AND accessibility*) OR TITLE-ABS-KEY(universal AND design* AND ergonomics AND workplace AND adaptation*) OR TITLE-ABS-KEY(barrier-free AND design* AND human-centered AND design* AND inclusive AND work AND environments) OR TITLE-ABS-KEY(diversity AND inclusion AND organizational AND performance* AND workplace* AND productivity) OR TITLE-ABS-KEY(employee AND engagement AND diverse AND teams AND social AND benefits AND of AND universal AND design*) OR TITLE-ABS-KEY(implementation AND challenges AND universal AND design* AND best AND practices) OR TITLE-ABS-KEY(workplace* AND accessibility AND design* AND standards AND policy AND guidelines) OR TITLE-ABS-KEY(universal AND design* AND evaluation AND systematic AND review AND research AND trends) OR TITLE-ABS-KEY(Literature

Review AND Comparative Analysis AND Universal Design Implementation Strategies)) AND (LIMIT-TO (SUBJAREA,"BUSI")) AND (LIMIT-TO (PUBSTAGE,"final")) AND (LIMIT-TO (SRCTYPE,"j")) AND (LIMIT-TO (LANGUAGE,"English"))

2.2. Web of Science (WoS)

universal AND design* AND workplace* AND organization AND accessibility* (All Fields)or **universal AND design* AND ergonomics AND workplace AND adaptation*** (All Fields)or **barrier-free AND design* AND human-centered AND design* AND inclusive AND work AND environments** (All Fields) or **diversity AND inclusion AND organizational AND performance* AND workplace* AND productivity** (All Fields) or **employee AND engagement AND diverse AND teams AND social AND benefits AND of AND universal AND design*** (All Fields) or **implementation AND challenges AND universal AND design* AND best AND practices** (All Fields) or **workplace* AND accessibility AND design* AND standards AND policy AND guidelines** (All Fields) or **universal AND design* AND evaluation AND systematic AND review AND research AND trends** (All Fields) or **literature AND review AND comparative AND analysis AND universal AND design AND implementation AND strategies** (All Fields) and **Article** or **Review Article** or **Proceeding Paper** (Document Types) and **Management** (Web of Science Categories)

2.3. PubMed

Universal Design, Workplace Organization, Accessibility; Inclusive Design, Physical Accessibility, Digital Accessibility, Social Inclusion; Universal Design, Ergonomics, Workplace Adaptation; Barrier-Free Design, Human-Centered Design, Inclusive Work Environments; Diversity and Inclusion, Organizational Performance, Workplace Productivity; Employee Engagement, Diverse Teams, Social Benefits of Universal Design; Implementation Challenges, Universal Design, Best Practices; Workplace Accessibility, Design Standards, Policy Guidelines; Universal Design Evaluation, Systematic Review, Research Trends; Literature Review, Comparative Analysis, UD Implementation Strategies.

The authors focused mainly on the publications that included the following categories:

- application of Universal Design in diverse areas: digital, social, and physical accessibility,
- challenges and barriers to implementing UD,
- benefits of implementing UD in the workplace.

The research process was also based on the identification of research gaps in various areas of management and universal design, especially in relation to specific groups of employees (e.g. seniors, people with different disabilities).

After the research according to the strategy described above, the authors conducted a content analysis of the titles and abstracts of the articles, considering only material relevant to the research topic. The final sample consisted of 14 articles and other publications.

In the final stage, the authors conducted an in-depth qualitative analysis of the content of selected publications.

To ensure that good quality publications were selected for analysis, the authors established quality assessment criteria such as: reputation of scientific journal or other source; the number of citations (impact factor), the methodology of research (e.g. empirical research, systematic reviews); topicality of the publication and relevance of the topic.

3. Results

As a result of using the search in **Scopus**, the authors found 5 articles according to the following limits:

- publish stage – final,
- document type – final,
- subject area – UD in the workplace,
- language – English,
- years of publications – 1996-2024.

The authors identified thematic categories related to management, as shown in Table 1.

Table 1.
Key results – subject areas, in the context of UD in Management (Scopus)

No.	Authors	Title of the publication, source, year	Thematic category	Corresponds to the topic of the research (yes/no)
1	Torres, E.N. (Torres, 2024)	Why great service is difficult to achieve: insights from theory and practice, International Journal of Contemporary Hospitality Management, 2024	The study examines the challenges of developing and implementing theory in service marketing and hospitality management. Key thematic areas: challenges of the marketing theory, implementation of service theory, theory-practice gap, human resources management, customers' behaviors.	No
2	Venter, A., de Vries, M. (Venter, de Vries, 2023)	Demonstrating the Elaborated Action Design Research (eADR) Model to Address Communication Challenges During Software Development, Systemic Practice and Action Research, 2023	The text describes a study conducted at CGIS, where ineffective communication during software development led to delays and quality issues in projects. Key thematic areas: communication in IT, effective communication.	No

Cont. table 1.

3	Coetzer, G. (Coetzer, 2016a)	An empirical examination of the mediating influence of time management on the relationship between adult attention deficit and role stress, Personnel Review, 2016	The study empirically examined the impact of time management on the relationship between adult attention deficit (ADD) and job role stress. Key thematic areas: time management, attention deficit hyperactivity disorder, occupational stress.	Yes
4	Singh, S., Kumar, R., Kumar, U. (Singh et al., 2015)	Applying human factor analysis tools to a railway brake and wheel maintenance facility, Journal of Quality in Maintenance Engineering, 2015	Ergonomics and human factors in the context of maintenance tasks (case study: railway workshop). It analyzes aspects such as technicians' posture, repair time and perception of job demands. Key thematic areas: ergonomics, human factor, safety.	Yes
5	Tu, K.-J., Loftness, V. (Tu, Loftness, 1998)	The effects of organisational workplace dynamics and building infrastructure flexibility on environmental and technical quality in offices, Journal of Corporate Real Estate, 1998	Study of the impact of changing working conditions on the quality of the office environment and infrastructure. It analyzes the relationship between dynamic changes in the organization of workspace (e.g. density of workstations, equipment) and the stiffness of building infrastructure, especially HVAC systems, lighting and telecommunications. The study showed statistically significant relationships between these factors and employee satisfaction. Key thematic areas: workplace dynamics, flexible infrastructure, the quality of workplace environment, employees' satisfaction.	Yes

Source: Own sources based on literature review

As a result of using the search in **WoS**, the authors found 10 publications (years 2008-2024), according to the following publication types: journals and book chapters. The main information on the authors, and the publication, as well as the thematic category are listed in the table below.

Table 2.
Key results – subject areas, in the context of UD in Management (Web of Science)

No.	Authors	Title of the publication, source, year	Thematic category
1.	Moody, L., Saunders, J., Rebernik, N., Leber, M., Curin, A., Wójcik-Augustyniak, M., Szajczyk, M.	Tackling Barriers to the Inclusion of Disabled People in the European Workplace Through Ergonomics, Part of the book series: Advances in Intelligent Systems and Computing (AISC, vol. 498), 2016	The ERGO WORK project implemented by academic and business partners focuses on identifying and eliminating barriers to exclusion in the workplace. Preliminary research has shown the need to improve the working conditions of disabled people and to train employees and employers in ergonomics and universal design. The projects brought together business, disabled employees, students and scientists, focusing on adapting workplaces, designing tasks and products to individual needs. Key thematic areas: inclusion in workplace, ergonomics and design, training in ergonomics, workplace adaptation. **Corresponds to the subject of the research.**
2.	Torres, E.N.	Why great service is difficult to achieve: insights from theory and practice, International Journal of Contemporary Hospitality Management, 2023	The study examines the challenges of developing and implementing theory in service marketing and hospitality management. Key thematic areas: challenges of the marketing theory, implementation of service theory, theory-practice gap, human resources management, customers' behaviors. **Does not correspond to the subject of the research.**
3.	Steyn, M.	Organisational benefits and implementation challenges of mandatory integrated reporting Perspectives of senior executives at South African listed companies, Sustainability Accounting, Management and Policy Journal, 2014	The study examines the perceptions of the benefits and challenges of implementing integrated reporting (IR) among CEOs, CFOs and other senior managers of South African listed companies. Key thematic areas: Integrated Reporting in South Africa, challenges of IR implementation. **Does not correspond to the subject of the research.**
4.	Usman, L.	Assessing the universal basic education primary and Koranic schools' synergy for Almajiri street boys in Nigeria, International Journal of Educational Management, 2008	The paper examines the policy's management implementation practices and challenges, as well as provides policy options that may minimize discrepancies for effective management. Major findings include the boys' adoption to the free lunch feeding policy as motivation to partial school attendance. Management shortcomings of the synergy include ineffective communication and collaboration, poor instructional supervision and cultural insensitivity to boys' school retention. Key thematic areas: policy's management implementation practices and challenges, discrepancies for effective management. **Does not correspond to the subject of the research.**

Cont. table 2.

5.	Venter, A., de Vries, M.	Demonstrating the Elaborated Action Design Research (eADR) Model to Address Communication Challenges During Software Development, Systemic Practice and Action Research, 2023	The text describes a study conducted at CGIS, where ineffective communication during software development led to delays and quality issues in projects. Key thematic areas: communication in IT, effective communication. **Partially correlates with the topic of the research.**
6.	Busco, C., Walters, J., Provoste, E.	Stakeholder management within PPP-arranged civil engineering megaprojects: a systematic literature review of challenges, critical success factors and stakeholder roles, 2024	This paper focuses on the interplay between stakeholder management, challenges, critical success factors (CSFs), and the overall success of PPP-arranged civil infrastructure megaprojects. Key thematic areas: PPP project management, stakeholder involvement. **Does not correspond to the subject of the research.**
7.	Coetzer, G.	An empirical examination of the mediating influence of time management on the relationship between adult attention deficit and role stress, Personnel Review, 2016	The study empirically examined the impact of time management on the relationship between adult attention deficit (ADD) and job role stress. Key thematic areas: time management, attention deficit hyperactivity disorder, occupational stress. **Partially correlates with the topic of the research.**
8.	Miles, A., Fleming, M., McKinney, A.P.	Retaliation: legal ramifications and practical implications of discriminatory acts in the workplace, Equality, Diversity and Inclusion, 2010	The purpose of this paper is to review retaliation legislation to clarify for employers and employees the protected provisions and provide guidance for complying with this important anti- discrimination statute to aid in promoting a fair and unbiased work environment. Key thematic areas: anti-discrimination law in workplace. **Does not correspond to the subject of the research.**
9.	Baranchenko, Y., Yukhanaev, A.	Barriers to Using Qualitative Methods in Business and Management Research in Ukraine, Proceedings of the 12th European Conference on Research Methodology for business and management studies, 2013	The authors in the article indicate obstacles to conducting qualitative research and discrepancies between the education systems in Western Europe and the former USSR countries. The results help understand the challenges of harmonizing the Ukrainian education system with international standards. Key thematic areas: higher education reform, academic traditions in the USSR. **Does not correspond to the subject of the research.**
10.	Popovic, D., Slivar, I., Bozac, M.G.	Accessible Tourism and Formal Planning: Current State of Istria County in Croatia, MDPI, Administrative Sciences, 2022	The article analyzes the tourist market, focusing on the needs of older people, families with small children and people with disabilities. The study highlights the importance of tourism accessibility, covering physical, information and service aspects. Key thematic areas: accessible tourism, adjusting infrastructure. **Corresponds to the subject of the research.**

Source: own sources based on literature review.

The authors identified 90 results in PubMed, as described in the table below. After analysing the titles and abstracts, 11 publications were identified as suitable for further analysis in the topic. After in-depth consideration of each of the publications, the authors identified 3 that were relevant to the research topic.

Table 3.
Results of the PubMed search - number of publications

No.	Key words	Results (number of publications)	Results (number of publications consistent with the research topic)
1.	Universal Design, Workplace Organization, Accessibility	13	4
2.	Inclusive Design, Physical Accessibility, Digital Accessibility, Social Inclusion	30	1
3.	Universal Design, Ergonomics, Workplace Adaptation	1	1
4.	Barrier-Free Design, Human-Centered Design, Inclusive Work Environments;	1	1
5.	Diversity and Inclusion, Organizational Performance, Workplace Productivity	12	3
6.	Employee Engagement, Diverse Teams, Social Benefits of Universal Design;	0	0
7.	Implementation Challenges, Universal Design, Best Practices;	18	0
8.	Workplace Accessibility, Design Standards, Policy Guidelines	5	1
9.	Universal Design Evaluation, Systematic Review, Research Trends	10	0
10.	Literature Review, Comparative Analysis, UD Implementation Strategies.	0	0
SUM		90	11

Source: Own sources based on literature review.

Table 4.
Further research results of the PubMed search - identification of the publications corresponding to the topic of the article

No.	Authors	Title of the publication, source, year	Content	Corresponds to the topic of the research (yes/no)
1.	Begnum, M.E.N., Igeltjørn, A.	Universal Design of Public Services: A Case Study of the Norwegian Labour and Welfare Administration. Stud Health Technol Inform, 2024	This paper presents how employees in a governmental organization strive towards incorporating universal design into their work practices when developing digital solutions – and what workplace aspects helps and hinders them in their efforts to ensure the digital services they build are accessible for all users.	Yes

Cont. table 4.

2.	Corcuff, M., Routhier, F., Paquette-Raynard, E., Gagnon, M., Battalova, A., Mwaka, C., Lamontagne, M.E.	Organizations' Strategies to Improve Implementation of Universal Accessibility Principles: Protocol for a Scoping Review. JMIR Res Protoc, 2022	The aim of this study is to identify strategies that are contextually appropriate and provide guidelines for organizations to promote successful implementation of universal accessibility. The results of this scoping review are expected to help the research community in various fields, local organizations, and stakeholders to identify better ways to improve implementation strategies of universal accessibility practices.	Yes
3.	Mueller, J.L.	Assistive technology and universal design in the workplace. Assist Technol. 1998	In the labor market, employers strive to stay competitive by attracting and maintaining a diverse workforce. A diverse workforce means different and unique needs among employees. One way employers can meet these needs is by using equipment that includes universal design (UD) features. UD features are integrated into devices, environments, processes, and systems such as architecture, kiosks, telecommunications, restrooms, and workplace elements. This publication provides helpful tips for choosing equipment that includes UD features, a process for choosing AT for employees with disabilities, and resources for additional information.	Yes
4.	Dannenberg, A.L., Cramer, T.W., Gibson, C.J.	Assessing the walkability of the workplace: a new audit tool. Am J Health Promot. 2005	Walking can be incorporated into most people's daily routines if the process is made convenient by a well-designed built environment. Walkability rarely is assessed in the workplace, where adults spend much of their time. Facility planners may find this walkability instrument useful in identifying and eliminating barriers to convenient walking opportunities in workplaces such as office parks and university campuses.	No
5.	Trotman, N., McGinley, C.	Design and the Mind Engaging and Collaborative Workshops for the Neurodiverse. Stud Health Technol Inform. 2018	A central goal of Design and The Mind (DTM) is to demystify the invisible barriers and issues surrounding cognitive, physical, digital access and engagement with the Wellcome Collection Hub, the wider organisation and Hub partners to improve inclusion and accessibility, and its resources; this approach formed an integral and positive part of the design process, through spotlighting opportunities for innovation. This paper highlights the most salient observations of a live research project. This project seeks to reframe notions and approaches for engagement with neurodiverse groups and individuals using a developed design suite of functioning and dynamic tools and methods underpinned by inclusive principled guidelines.	Yes

Cont. table 4.

6.	Gonzalez, I., Morer, P.	Ergonomics for the inclusion of older workers in the knowledge workforce and a guidance tool for designers. Appl. Ergon., 2016	The ageing of the population and the inverted population pyramid is bringing important changes to society as a whole. These changes are associated with the inclusion of an older workforce in knowledge work and the challenge they represent in adapting the work environment accordingly. In order to approach a more universal design of the work environment, industrial designers need support from user-sensitive inclusive design studies. there is a need to develop more appropriate tools for Industrial Designers that cover the initial phase of the design process. This study provides a review of the available tools and guidelines and proposes a theoretical framework intended for developing a design guidance tool for inclusive workstation design.	Yes
7.	Burelli, A., Simone, C.	Policies and Processes for Accessibility from a UD Perspective: The Integrated Approach Supported by the Friuli Venezia Giulia Region (IT). Stud Health Technol. Inform. 2022	In order to promote change and to impart this change of approach, the Autonomous Region of Friuli Venezia Giulia has envisaged integrated actions, aimed, as a whole, at accompanying the process that guides the project culture towards a progressive adherence to the methodological criteria of Universal Design, introducing, at the same time, support measures aimed at financing the Municipalities of the Region both for the preparation of barrier elimination plans (PEBAs) and the implementation of the interventions identified in those plans. Among the envisaged actions, the most important is a general accessibility mapping, which includes the adoption of a terminology system (accessibility ontology) integrated in a specific computer application, through which the municipalities will be able to detect architectural barriers, in a homogeneous way, over the entire regional territory.	No
8.	Gross-Gołacka, E., Kupczyk, T., Wiktorowicz, J.	Towards a Better Workplace Environment-Empirical Measurement to Manage Diversity in the Workplace. Int. J. Environ. Res. Public. Health. 2022	The use of quantitative methods in the decision-making process of an organization can have a significant impact on the quality of its management. In the case of building an inclusive environment and implementing activities for diversity management, the proposed 5P architecture (planning, processes, people, possessions, and profits) could significantly support this process. Therefore, it is recommended to use the proposed 5P architecture in practice, for example, to diagnose the scope and quality of actions taken for diversity management, as well as to build a diverse working environment in key areas of the organization.	Yes

Cont. table 4.

9.	Liu, J., Zhu, Y., Wang, H.	Managing the negative impact of workforce diversity: The important roles of inclusive HRM and employee learning-oriented behaviors. Front Psychol. 2023	Based on the workplace diversity theories (e.g., the categorization-elaboration model), this study examined how workforce diversity was positively related to interpersonal conflict through impacting one's affective states, and to what extent this indirect effect can be weakened by organization-initiated practices (i.e., the inclusive human resources management (HRM) practices) and employee-initiated behaviors (i.e., employee learning-oriented behaviors).	Yes
10.	McGann, S., Jancey, J., Tye, M.	Taking the stairs instead: The impact of workplace design standards on health promotion strategies. Australas. Med. J. 2013	This paper is aimed at highlighting the gap in health promotion knowledge by addressing how the disciplines of architecture and health promotion can work together to challenge the regulations that dictate design practice and ultimately bridge that gap for long-term change. The overarching aim is to undertake further evidenced-based research that will inform best practice in the planning and design of workplaces to reduce sedentary behaviour and increase opportunities for physical activity.	No

Source: Own sources based on literature review.

4. Theoretical Background

The inspirations for the meaning of Universal Design started in the 1960s, with the first legislation in the US: the Civil Rights Movement of the 1960s inspired the Disability Rights Movement that greatly influenced the legislation of the 1970s, 1980s, and 1990s. These new laws prohibited discrimination against people with disabilities and provided access to education, places of public accommodation, telecommunications, and transportation". The very concept originated in the fields of architecture and design. Its definition was coined by Ronald L. Mace, architect and product designer. He stated the term universal design as a concept of designing products and environments for the needs of people, regardless of their age, ability or status in life (Persson et.al., 2014). In 2001 the Committee of Ministers of the Council of Europe accepted the final version of the definition of Universal Design: "Universal design is a strategy that aims to make the design and composition of different environments and products usable for everyone. It attempts to do this in the most independent and natural manner possible, without the need for adaptation or specialized design solutions. The intent of the universal design is to simplify life for everyone by making the built environment, products and communications equally accessible, usable, and understandable at little or no extra cost. The universal design concept emphasizes user-centred design by following a holistic approach to accommodate the

needs of people of all ages, sizes and abilities. It provides for the changes that all people experience throughout their lives. Consequently, universal design is becoming an integral part of architecture, design and planning of the built environment" (Null, 2014).

According to the Center for Universal Design (1997) there are seven main Universal Design principles:

1. Equitable Use - the design is useful and marketable to people with diverse abilities.
2. Flexibility in Use - The design accommodates a wide range of individual preferences and abilities.
3. Simple and Intuitive Use - The use of the design is easy to understand, regardless of the user's experience, knowledge, language skills, or current concentration level.
4. Perceptible Information - The design communicates necessary information effectively to the user, regardless of ambient conditions or the user's sensory abilities.
5. Tolerance for Error - The design minimizes hazards and the adverse consequences of accidental or unintended actions.
6. Low Physical Effort - the design can be used efficiently and comfortably and with a minimum of fatigue.
7. Size and Space for Approach and Use - Appropriate size and space is provided for approach, reach, manipulation, and use regardless of the user's body size, posture, or mobility.

There are some key categories of accessibility; the ones most frequently described in the literature are listed in the table below.

Table 5.
Key categories of accessibility, with examples of literature sources

Category of accessibility	**Description**	**Examples of literature sources**
Digital	Digital accessibility means that websites, tools, and technologies are designed and developed so that people with disabilities can use them (World Wide Web Consortium W3C)	*W3C (2008). Web Content Accessibility Guidelines (WCAG) 2.0.* *Horton, Sarah & Quesenbery, Whitney (2013). A Web for Everyone: Designing Accessible User Experiences.* *Cooper, Alan, et al. (2014). About Face: The Essentials of Interaction Design* (Cooper, 2014; Horton, 2014)
Physical (architectural)	Refers to the design, construction, and modification of buildings and physical environments to ensure they can be accessed, used, and navigated by all individuals, including those with disabilities. It focuses on eliminating physical barriers that may prevent people with mobility, sensory, or cognitive challenges from fully utilizing spaces.	Mace, Ronald L. (1985). *Accessible Environments: Toward Universal Design.* Preiser, Wolfgang F.E. (ed.) (2001). *Universal Design Handbook.* Ostrowska, Alicja (2008). *Architektura bez barier: podręcznik dla projektantów* (Mace, 1985; Ostrowska, 2008; Preiser, 2001)

Cont. table 5.

Informational	Refers to ensuring that all individuals, regardless of their abilities, can access, comprehend, and use information effectively.	W3C (2018). *Web Content Accessibility Guidelines (WCAG) 2.1.* *Gulliksen, Jan, et al. (2005). Making Information Usable and Accessible.* *Fajardo, Inmaculada, et al. (2014). Easy-to-Read Texts for People with Cognitive Disabilities.* (Fajardo, 2014; Gulliksen, 2005; W3C, 2018)
Communication	Refers to the ability of all individuals, regardless of their abilities or disabilities, to access and understand messages, information, and interactions. It ensures that everyone, including people with visual, auditory, cognitive, and physical disabilities, can engage in communication in an inclusive, meaningful, and effective way.	Beukelman, David & Mirenda, Pat (2013). *Augmentative and Alternative Communication.* W3C (2017). *Accessible Communication Formats: Guidelines for Effective Practices.*(Beukelman, 2013; W3C, 2017)
Educational	Refers to the design and implementation of educational environments, tools, and content that ensure all students, regardless of their abilities or disabilities, can fully participate in learning opportunities.	Rose, David H. & Meyer, Anne (2002). *Teaching Every Student in the Digital Age: Universal Design for Learning.* Burgstahler, Sheryl (2015). *Universal Design in Higher Education: From Principles to Practice.* Hehir, Thomas (2009). *Effective Inclusive Schools: Designing Successful Schoolwide Programs* (Burgstahler, 2015b; Hehir, 2009; Rose, 2002).
Social	Aims to remove barriers that prevent individuals, especially those with disabilities or other marginalized groups, from fully participating in social, cultural, and community activities. It is about creating an inclusive environment where everyone, regardless of their abilities, social status, or identity, can engage in social, recreational, and community life.	Oliver, Michael (1990). *The Politics of Disablement.* Shakespeare, Tom (2013). *Disability Rights and Wrongs Revisited.* Barnes, Colin (1991). *Disabled People in Britain and Discrimination (Burgstahler, 2015a; Hehir, 2009; Rose, 2002)*
Sensory	The goal of sensory accessibility is to ensure that all people, regardless of their sensory abilities, can fully engage with and participate in their environment, whether it's public spaces, digital co tent, or social interactions.	Calvillo-Arbizu, Jorge, and Badiola, Kepa (2015). *Universal Design and Accessibility for Sensory Disabilities in Public Spaces.* *Gulliksen, Jan et al. (2015). Universal Design as a Practical Strategy for Accessible ICT.* *Tobias, Jon L. (2017). Accessible Environments for the Visually Impaired.* *Loomis, Jack M. et al. (2012). Visual Accessibility: Advances in Orientation and Mobility Technology.* *Napier, Jemina, and Leeson, Lorraine (2016). Sign Language in Action.* *Farina, Barbara (2018). Hearing Accessibility in Public Spaces: Acoustics and Assistive Devices.* *Mostafa, Magda (2014). Architecture for Autism: Autism ASPECTSS Design Index.* (Calvillo-Arbizu, 2015; Farina, 2018; Gulliksen, 2015; Loomis, 2012; Mostafa, 2014; Napier, 2016; Tobias, 2017)

Source: Own sources based on literature review.

Legal context

There are international and national regulations that promote the idea of universal design, and they result from such ideas as equality, accessibility, or counteracting exclusion. Key legal acts and standards related to the UD concept are described below:

1. International law:
   - UN Convention on the Rights of Persons with Disabilities (CRPD), 2006. The CRPD introduces the concept of UD - products, environments, programs and services should be designed in a way that allows everyone to use them, without the need for adaptation or specialized solutions. What is more, in article 4, the states are obliged to take legislative, administrative and other actions to implement the principles of accessibility, promote research and development of technologies and accessible products that comply with the principles of UD, and eliminate architectural, communication, technological and other obstacles and barriers. The most important article in the context of UD is article 9, in which states are obliged to ensure the availability of: buildings, roads, transport and other public space, information and communication services, including digital technologies, and mass media. This article requires the application of UD principles, to enable people with disabilities to independently use spaces, products and services.
   - UN 2030 Agenda for Sustainable Development - goal 11 “Sustainable cities and communities” emphasizes the need to create inclusive and accessible urban spaces.
2. EU regulations:
   - European Accessibility ACT (EAA) 2019 aims to facilitate access to products and services with disabilities; stimulating the EU internal market in terms of available products and services; reducing barriers and differences in accessibility rules between member states. All products and services must be designed in accordance with the principles of UD. All the provisions have to be applied to national legislation till June 28th 2025.
3. Polish regulations:
   - Constitution - guarantees equality and prohibition of discrimination (art. 32).
   - Polish Act on ensuring accessibility for people with special needs 2019 - a key legal act regulating accessibility issues in Poland, developed in response to requirements arising from: CRPD, EAA and national obligations in the field of counteracting social exclusion.
   - Labor code - regulations related to the adaptation of workplaces of people with disabilities (art. 207).

4. Technical standards (examples):
   - ISO 21542: *Building Construction – Accessibility and Usability of the Built Environment* - provides guidelines for designing buildings and facilities that are accessible to all users.
   - **ISO 9241**: *Ergonomics of Human-System Interaction* - focuses on the usability of interactive systems, including accessibility for digital products like software, hardware, and interfaces.
   - **EN 301 549**: *Accessibility Requirements for ICT Products and Services.*
   - Web Content Accessibility Guidelines (European standard for ICT accessibility) - an international standard for the accessibility of Internet content.

5. Discussion

The above analyses have revealed a relatively small number of articles describing the phenomenon under study. What is surprising is the relatively small number of these articles describing the phenomenon in detail in typical scientific databases such as Scopus and Web of Sciences. More detailed analyses can be found in the articles listed in the PubMed search engine, as will be shown below.

Table 6 below provides a list of the articles identified in Scopus, WoS and PubMed according to the search strategy that answers the research questions and correlates with the main and specific aims of the article.

Table 6.
Analysis of articles in Scopus, WoS, and PubMed to answer the research questions and correlation with the main and specific objectives

Literature database	Author	Answers for Research Questions	Correlation with the main goal	Correlation with the specific goals (G)
Scopus	1. (Coetzer, 2016)	**RQ1** Touches on cognitive accessibility by discussing time management as a means of reducing stress in the workplace. **RQ2** Suggests that addressing cognitive needs (e.g., through time management tools) improves workplace productivity.	Limited relevance. The article examines occupational stress, which indirectly touches on cognitive accessibility (e.g., accommodating employees with ADHD).	G1. Cognitive accessibility G3. Indirectly through time management G3. Benefits: reduced stress; lacks broader UD applicability.
	2. (Singh et al., 2015)	**RQ1** Focuses on **physical accessibility** through ergonomic adjustments to improve technician safety and efficiency. **RQ2** Shows how workplace adaptations can reduce physical	Strongly correlated. The article examines **ergonomics** and workplace adaptations, directly addressing physical	G1. Physical accessibility G2. Ergonomic tools, workplace design

		strain and improve task performance. **RQ3** Emphasises the benefits of ergonomic design in terms of increased safety, productivity and employee wellbeing. **RQ4** Identifies the need for task-specific tools and training to implement ergonomic solutions.	accessibility in workplace organisation	G3. Benefits: safety, productivity. Challenges: training needs.
	3. (Tu, Loftness, 1998)	**RQ1** Focuses on **physical and environmental accessibility**, emphasising adaptable infrastructure (e.g., HVAC systems, lighting). **RQ2** Demonstrates how infrastructure flexibility can meet diverse workplace needs, improving inclusion and satisfaction. **RQ3** Shows statistically significant links between infrastructure adaptability and employee satisfaction. **RQ4** Discusses the difficulty of retrofitting rigid infrastructure and the importance of proactive planning.	Strongly correlated. This article explores how flexible infrastructure supports workplace adaptability in line with UD principles.	G1. Physical, environmental accessibility G2. Flexible infrastructure G3. Benefits: adaptability, satisfaction. Challenges: retrofitting.
WoS	1. Moody et al. (2016)	**RQ1** Addresses physical accessibility and social inclusion through ergonomic adaptations and training. **RQ2** Demonstrates how UD principles improve workplace accessibility for employees with disabilities. **RQ3** Highlights benefits such as increased inclusivity, improved working conditions, and employee satisfaction. **RQ4** Discusses challenges such as lack of awareness and the need for targeted training.	Strongly correlated. Addresses **physical and social accessibility** through ergonomic design and workplace adaptation. Highlights applications of UD (e.g., training and accommodation). Discusses benefits (inclusiveness, satisfaction) and challenges (lack of awareness).	G1. Physical, social accessibility G2. Ergonomic design, workplace adaptation G3. Benefits: inclusivity, satisfaction. Challenges: training needs.
	2. Venter, de Vries (2023)	No answer to the research questions.	Partially correlated: - Discusses communication accessibility **in** IT projects. Relevant to a narrow aspect of workplace accessibility but lacks general UD applications.	G1. Communication accessibility (limited) G2. Indirectly addresses IT environments G3. Highlights communication challenges but lacks broader UD context.

	3. Coetzer (2016)	**RQ1:** Addresses cognitive accessibility by exploring stress reduction strategies for people with ADHD. **RQ2:** Suggests addressing cognitive needs through time management tools to improve productivity.	Partially correlated: - Addresses cognitive accessibility (e.g., stress management for employees with ADHD). Highlights indirect UD applications such as time management tools.	G1. Cognitive accessibility G2. Time management tools G3. Benefits: reduced stress. Lacks broader UD applicability.
	4. Popovic et al. (2022)	**RQ1** Discusses physical and information accessibility in the context of tourism, with applications to workplace accessibility. **RQ2** Demonstrates how infrastructure changes can accommodate different user needs. **RQ3** Highlights benefits such as increased inclusivity and user satisfaction.	Strongly correlated - Examines physical and informational accessibility in infrastructure. Highlights UD applications (e.g., infrastructure adaptations for accessibility). Discusses benefits (inclusivity) and challenges (cost of retrofitting).	G1. Physical, informational accessibility G2. Infrastructure adjustments G3. Benefits: inclusivity, user satisfaction. Challenges: retrofitting.
PubMed	1. Begnum et al. (2024)	**R1.** Focuses on digital and communication accessibility, addressing workplace barriers to accessibility in digital solutions. **R2**. Emphasises efforts to create accessible digital services for diverse users. R3. Improving the inclusivity and usability of digital services. **R4.** Challenges: Limited resources and resistance to putting UD principles in practice. **Best practices:** Training employees and collaborative design of digital tools.	Strongly correlated - Addresses digital and communication accessibility**.** Discusses UD applications in public services. Highlights barriers, training, and collaborative design as key practices.	G1. Digital, communication accessibility G2. Accessible digital service design G3. Highlights barriers, emphasizes training, and collaborative design.
	2. Corcuff et al. (2022)	**R1.** Discusses strategies for **physical and social accessibility**. **R2.** Identifies effective strategies for implementing UD principles, such as stakeholder engagement and contextual adaptation. **R3**. **Benefits:** increased inclusivity in the workplace and improved adoption of accessibility practices. **R4. Challenges:** Contextual variations and inconsistencies in implementation. **Best practices:** Tailored strategies and collaborative efforts.	Strongly correlated - Covers physical and social accessibility**.** Identifies strategies for implementing UD. Emphasises contextual variations and the importance of stakeholder involvement.	G1. Physical, social accessibility G2. Tailored UD implementation strategies G3. Benefits: inclusivity. Challenges: contextual variations.

	3. Mueller (1998)	**R1.** Focuses on physical and digital accessibility through assistive tools and workplace features. **R2.** Demonstrates how assistive technology (AT) and UD features can be integrated into workplace environments (e.g. restrooms, kiosks). **R3.** Inclusion, productivity, and satisfaction for employees with disabilities. **R4. Challenges:** Financial and technical constraints. **Best practices:** Choosing cost-effective and adaptable tools for different needs.	Strongly correlated - Focuses on physical and digital accessibility through assistive technologies. Demonstrates UD applications in the workplace environment. Highlights the challenges of inclusivity and cost.	G1. Physical, digital accessibility G2. Assistive technologies and tools G3. Benefits: inclusivity, productivity. Challenges: cost, adaptability.
	4. Trotman, McGinley (2018)	**R1.** Focuses on removing invisible barriers for neurodiverse people through collaborative design. **R2.** Collaborative design processes for neurodiverse groups promote innovation in workplace solutions. **R4.** Cognitive and invisible accessibility needs are often overlooked. Involving neurodiverse people in the design process leads to better outcomes.	Strongly correlated - Explores cognitive, digital, and social accessibility**.** Demonstrates collaborative design to address neurodiverse needs. Identifies innovation as a benefit of UD.	G1. Cognitive, digital, social accessibility G2. Collaborative design for neurodiverse groups G3. Benefits: innovation. Challenges: addressing invisible barriers.
	5. Gonzalez, Morer (2016)	**R1.** Discusses ergonomic design for older workers to accommodate age-related physical limitations. **R2.** Ergonomic design improves working conditions for older workers, leading to higher retention. **R3.** Ergonomic tools support the health and well-being of older workers. **R4.** Incorporating UD principles during the initial design stage avoids costly retrofitting.	Strongly correlated – Addresses **physical and social accessibility**, focusing on ergonomic design for older workers. - Emphasises user-sensitive frameworks and inclusivity in the workplace.	G1. Physical, social accessibility G2. Ergonomic workstation design G3. Benefits: retention, wellbeing. Challenges: user-sensitive design
	6. Gross-Gołacka et al. (2022)	**R1.** Discusses diversity management frameworks to promote inclusiveness in the workplace. **R2.** Inclusive frameworks (e.g., 5P architecture) create environments that meet the needs of diverse workforces. **R3.** Structured frameworks improve decision making and workplace efficiency.	Partially correlated - Focuses on social accessibility and diversity management frameworks (5P). Relevant to workplace inclusivity but lacks focus on wider UD applications.	G1. Social accessibility G2. Inclusive frameworks (5P) G3. Benefits: workplace diversity. Challenges: measuring inclusivity.

	7. Liu et al. (2023)	R3. Inclusive HR practices reduce interpersonal conflict in diverse workplaces.	Partially correlated - Addresses diversity and **social accessibility** but lacks a specific focus on UD or workplace applications.	G1. Social accessibility. G2. **Applications:** Inclusive HRM and learning-oriented practices for diverse workplaces. G3. **Benefits:** Reduction in workplace conflicts and enhanced diversity management. **Challenges:** Limited focus on physical or cognitive accessibility.

Source: Own sources based on literature review.

The table above shows that the use of UD in workplace design and organisation should address accessibility needs while promoting inclusion, productivity and employee satisfaction. This discussion synthesises the findings from the literature and relates them to the research questions and specific objectives of the analysis in the areas of physical, digital, information, communication, social and sensory accessibility of workplaces.

From the detailed analysis of the articles, the following findings emerge as a platform for further research in this area:

Areas of accessibility

a. Physical accessibility

Several articles highlight the importance of physical accessibility as a basis for the use of UD in the workplace:

- Singh et al. (2015) emphasise the role of ergonomic adaptations in improving the safety and performance of the technicians, reducing physical strain and increasing productivity. This is in line with (G1) on physical accessibility and emphasises the importance of task-specific tools and training (G2).
- Gonzalez, Morer, (2016) further emphasise the importance of ergonomic designs adapted to an ageing workforce, which contributes to employee retention and wellbeing. Incorporating UD principles at the design stage avoids costly retrofitting (G3).

b) Digital accessibility

Digital accessibility remains a critical area for workplace inclusion:

- Begnum, Igeltjørn, (2024) focus on the development of accessible digital services in public organisations. The study highlights the challenges of limited resources and resistance to adopting UD principles but emphasises training and co-design as key strategies (G2, G3).

- Mueller, J.L. (1998) shows how assistive technologies and digital tools, such as kiosks and telecommunications systems, can increase inclusion and productivity in the workplace (G1, G2, G3).

c) Cognitive accessibility

Cognitive accessibility is crucial in supporting neurodiverse employees and those with specific cognitive needs:

- Coetzer (2016b) addresses the relationship between time management tools and reduced stress in employees with ADHD. This highlights the indirect use of UD through cognitive accessibility (G1, G2).
- Trotman, McGinley, (2018) advocate collaborative design process to address the invisible barriers encountered by neurodiverse employees. Their findings suggest that involving employees in the design process promotes innovation and better workplace solutions (G2, G3).

d) social accessibility.

Social inclusion frameworks also play a key role in UD in the workplace:

- Gross-Gołacka et al. (2022) propose a 5P architecture (planning, process, people, ownership, profit) for managing diversity in the workplace. This framework supports decision making, improves inclusion and increases workplace productivity (G1, G2, G3).
- Liu et al. (2023)explore inclusive HR practices and learning-oriented behaviours to mitigate interpersonal conflict in diverse workplaces. These practices are consistent with social accessibility goals while improving collaboration and employee wellbeing (G3)

The benefits of universal design are also described in the literature. These include:

a) Inclusion and diversity: Moody, (2016) and Corcuff et al. (2022) highlight how UD promotes inclusion by enabling employees with diverse needs to participate fully in the workplace.
b) Increased productivity: Singh et al. (2015) and Mueller, J.L. (1998) show that ergonomic adaptations and assistive technologies directly contribute to increased productivity by reducing physical strain and increasing workers' capabilities.
c) Employee retention and satisfaction: Gonzalez, Morer, (2016) show how UD principles increase employee satisfaction and retention, especially for ageing workers.

The literature review also highlights the challenges of implementing UD. While the benefits of UD are clear, several challenges hinder its widespread adoption:

a) Financial constraints: As noted by Mueller, J.L. (1998), the cost of upgrading infrastructure and implementing assistive technologies can be prohibitive.

b) Awareness and training: Moody (2016) and Begnum, Igeltjørn, (2024)and Begnum et al. (2024) highlight the lack of organisational knowledge and training in UD principles, which limits effective implementation.
c) Adaptation: (Corcuff et al., 2022) emphasise that UD strategies need to be adapted to specific organisational and cultural intentions.

The above considerations highlight esearch gaps and future trends in the use of UD in workplace design. Few articles make explicit reference to sensory accessibility, such as accommodation for hearing or visual impairments. Future research should include tactile navigation systems, visual alarms and other sensory-friendly workplace solutions. In addition, there is limited research on how advanced technologies such as IoT, AI and AR/VR can make workplaces more accessible. Exploring their potential to create adaptive and responsive environments is a key area for future research. The long-term impact of UD on productivity, diversity and employee wellbeing in the workplace remains under-researched. Most descriptions analyse general applications of UD without considering the unique requirements of specific industries, such as healthcare, retail or manufacturing. Sector-specific research would enable UD strategies to be adapted.

In summary, the application of UD principles in workplace organisation increases inclusion, productivity and employee satisfaction while meeting diverse accessibility needs. However, financial constraints, limited awareness and gaps in sensory and technological applications hinder the full potential. By addressing these challenges and expanding research into new technologies, sensory accessibility, and industry strategies, organisations can create realistically inclusive and flexible workplaces for all employees.

6. Conclusion

The above discussion provides some critical insights into the application of universal design (UD) in workplace design, addressing the different dimensions of accessibility, the benefits of implementing UD and the challenges encountered. General conclusions are presented below:

1. Applying UD in the workplace:
   - **Physical accessibility:**
     - Ergonomic adaptations (Singh et al., 2015; Gonzalez, Morer, 2016) and assistive technologies (Mueller, 1998) are key strategies for ensuring inclusive physical work environments.
     - Flexible infrastructure (Tu, Loftness, 1998) supports adaptability to the diverse needs of employees.

- **Digital accessibility:**
  - Accessible digital services (Begnum et al., 2024) and tools designed according to UD principles (Mueller, 1998) improve the inclusion of employees with disabilities.
- **Cognitive accessibility:**
  - Time management strategies (Coetzer, 2016) and collaborative design processes for neurodiverse workers (Trotman, McGinley, 2018) address cognitive barriers.
- **Social Accessibility:**
  - Diversity management frameworks (Gross-Gołacka et al., 2022; Liu et al., 2023) promote inclusion and reduce conflict in the workplace.

2. Benefits of Universal Design:
   - Increased **inclusivity** improves access for different groups of employees (Moody et al., 2016; Corcuff et al., 2022).
   - Increased **employee satisfaction** and retention, particularly for an ageing workforce (Gonzalez, Morer, 2016).
   - Increased **productivity** through assistive technologies and ergonomic design (Mueller, 1998; Singh et al., 2015).
   - Encourages **innovation** in workplace solutions by involving neurodiverse workers in co-design processes (Trotman, McGinley, 2018).
3. Challenges in implementing universal design:
   - **Financial constraints:** High costs of upgrading older infrastructure and purchasing assistive technology (Tu, Loftness, 1998; Mueller, 1998).
   - **Awareness and training:** Lack of organisational knowledge of UD principles hinders effective implementation (Moody et al., 2016).
   - **Contextual differences:** Strategies need to often be adapted to specific cultural, organisational or industrial contexts (Corcuff et al., 2022).
   - **Addressing invisible barriers:** Cognitive and sensory accessibility remains under-researched and poorly implemented (Trotman, McGinley, 2018).
4. Best practices for implementing universal design:
   - **Training programmes:** Educating employees and stakeholders about the principles of UD increases their acceptance (Begnum et al., 2024).
   - **Stakeholder engagement:** Collaboration between designers, workers and decision-makers ensures effective strategies (Corcuff et al., 2022).
   - **Early planning:** Incorporating sustainability principles at the initial design stage avoids costly retrofits (Gonzalez, Morer, 2016).
   - **Data-driven framework:** Tools such as the 5P architecture improve decision-making and integration efforts (Gross-Gołacka et al., 2022).

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