

# UNIVERSAL DESIGN AND EMPATHIC DESIGN FOR ENGINEERS

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## ABSTRACT

This article explores the relevance of universal design and empathic design in education. The universal design focuses on creating accessible and usable products, environments, and systems for individuals with diverse abilities. Empathy, on the other hand, involves understanding and sharing the feelings of others, encompassing cognitive, emotional, and compassionate empathy. The article investigates the application of empathy in design, particularly its importance for engineers. Teaching empathy to engineers is emphasized as a crucial aspect. By developing empathic skills, engineers gain a deeper understanding of user needs and perspectives, leading to more inclusive and user-centered design solutions. Effective communication techniques such as asking open-ended questions, active listening, observation, and perspective-taking are explored to enhance empathy in communication. The article also explores methods for measuring empathy, thus enabling engineers to assess the effectiveness of their empathic design approaches. The challenges facing students, teachers, and university authorities in implementing such courses are also bulleted. Med Pr. 2023;74(3):211–25

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## INTRODUCTION

Probably one of the great challenges faced by today's society is the design of products and services that, associated with everyday contexts, can enhance the capacity of each citizen to tackle and solve, without any type of discrimination, the problems inherent to their daily life. The search for this equality in society is, of course, an ongoing and never-ending task. Universal design, referred to sometimes as a concept, a process, or even a philosophy, encompasses a broad number of concerns that at their core converge towards the goal of designing experiences for the broadest number of people and, when possible, leaving the scarcest number of citizens behind.

The binomial “universal design” (UD), which is in some literature used alternately and simultaneously

with the term “design for all,” emerged in the 20th century as a proactive approach to design, especially comprehensive of the various human requirements, as opposed to the maxim “design for the average user” [1].

The definition of UD may vary depending on the profile of the person trying to define it [2]. For some, it is a politically correct term referring to the effort to introduce “special adaptations” for “special users” during the design process of a product or service. According to the others, UD is a deep and rich subject for reflection that elevates what can be called good user-based design [3] to a more prominent concept regarding satisfying everyone's needs. To promote this notion, some design endorsers have adopted the motto: “Good design enables, bad design disables” [4]. In essence, and without restriction to specific areas of intervention, UD can be

understood as the effort to design, develop and market products, solutions, systems and environments in current use to be accessible and usable by the greatest number of users [4,5].

It might be interesting to point out that this effort tends to lead, in many situations, to scenarios where the work aimed at satisfying the largest number of users ends up excluding those who, for one reason or another, are not fitting into the target group [6]. Many ideas, which are supposed to work for everyone, in many cases don't work for anyone [7,8].

The UD can be defined as a term that is used to reflect a new concept or a new philosophy in the world of design that recognizes, respects, values and tries to accommodate the greatest possible number of abilities, skills, requirements and preferences in the design of computer-based products and services and interaction platforms. Interaction platforms comprise all tools in a software format that provide implemented solutions or means that enable the implementation of interactive elements that in turn allow the construction of an interface for the user [3]. Examples include Windows in its various versions, structuring languages such as HTML and XML, formatting and presentation languages such as CSS, and object-oriented programming languages such as JAVA. From this perspective, UD promotes a stance that eliminates the need for "special adaptations" and promotes end-user individualization and acceptance [8].

As a fundamental idea, the UD states that one should design products and services with characteristics capable of being adopted by the widest possible range of users. When working towards these goals, the common ground should be to identify different solutions for different contexts of use. According to the definition given by the International Standards Organization (ISO), the context of use can be understood as the nature of the users, tasks and physical and social means by which a product or service is used.

The origins of the UD concept reflect, once again, the multiplicity of areas that can be touched by it. Its incidence exceeded, throughout the 20th century, the limits imposed by areas linked to demographic, legislative, and economic studies and work related to elderly people and/or people with special needs [1,9]. The definition of UD derives from progressive work spanning decades, people and movements. As a common denominator, however, there is a concern to improve the design of various elements linked to the activities carried out by people. Ron Mace's name appears associated with the creation of the term "universal design" in

the 70s. In 1989, this architect founded the Centre for Accessible Housing, subsidized by the National Institute on Disability and Rehabilitation Research (NIDRR), which in 1996 adopted the name of Centre for Universal Design, a name more consistent with the range of areas of intervention assumed by the organization. Its main concern was creating awareness, among the general public, of the existence of products that stood out, from others, due to their qualities in terms of usability.

The UD cannot be disassociated from other concepts such as user centred design (UCD), which has been an object of study for decades [10]. The correlation between such concepts stands out in the work of agents of this movement such as Charles and Ray Eames, Eero Saarinen, Edgar Kaufmann Jr., Dieter Rams, and Max Bill, who combine their concerns with creating an object of a high aesthetic level capable of lasting over the years. The concept of UCD adopted in work conducted by these renowned designers and innovators may seem a bit off track when looked at through the lens of other work in the field [11]. The concern with the user proves to be worthy of association with UCD because it recognizes that the design work carried out has the user as the final and most important agent to be satisfied with the result. The fact is that, in this search, some work tried to identify a sort of average user and assumed that by meeting their needs, a vast majority of users would be reached, thus fulfilling the goal of UD. Some initiative demonstrated that reality did not follow this line of logic and that, in fact, there was a need for quite a different approach. For example, some work carried out in the 60s sought to identify a hypothetical average user capable of representing the needs of the entire population. Dreyfuss [12] tried to find the universal man and woman, who intended to represent the common Americans, who gathered a set of physical and psychological characteristics shared by an average of the American population of the time. When trying to represent the set of common characteristics of the American population, Dreyfuss demonstrated that this does not exist. Vanderheiden [13] and his work help us to understand the issue of average user demand with greater acuity.

In the 60s, inspired by the civil rights movement, disabilities rights movement originated, that would influence some of the legislation passed and applied in the 70s, 80s and 90s towards people with special educational needs (SEN) and guarded their right to access education, telecommunications and transport [9]. The UD context that we intend to address within

the field of human-computer interaction (HCI), instead of looking at UD as a one-size-fits-all approach, takes into consideration a view through which solutions tend to encompass the potential of adaptability and adaptivity as means to match the user and the technologies. The following principles, developed by the Center for Universal Design and presented as applicable to any design, are a perfect example of how essential flexibility in UD solutions is. The 7 principles include [1]:

1. Equitable use: the design should be useful and accessible to people with diverse abilities.
2. Flexibility in use: the design should accommodate a wide range of individual preferences and abilities.
3. Simple and intuitive use: the design should be easy to understand and use, regardless of the user's experience, knowledge, language skills, or current concentration level.
4. Perceptible information: the design should provide information in multiple ways to accommodate different sensory abilities and preferences.
5. Tolerance for error: the design should minimize hazards and errors and provide failsafe features to prevent serious consequences from user errors.
6. Low physical effort: the design should be efficient and comfortable to use, with minimal physical effort.
7. Size and space for approach and use: the design should provide enough space for users to reach, manipulate, and operate the design, regardless of their body size, posture, or mobility.

Universal design is crucial as it fosters inclusion, autonomy, and social engagement for persons of all capabilities. It acknowledges that diverse individuals have different demands and skills and that a design that works well for one individual may not work well for another.

### Empathy – general definition

According to extensive work done by different authors [14,15], defining empathy is not a simple and straightforward task and may vary widely depending on its nature. It is however agreed that empathy is a complex and multifaceted concept that cannot be fully understood by focusing on just one dimension. Rather, it should be viewed as encompassing a variety of factors, including intellectual, emotional, behavioral, and moral. Furthermore, considering empathy from an individual perspective creates an ethical dimension which enhances our understanding of empathy and allows further understanding of how others feel from their point of view. It involves imagining what it's like to be in their

shoes and feel what they feel [16]. Empathy helps us build strong relationships by connecting with people on an emotional level. It is a complex psychological process that involves multiple components, such as perspective-taking, emotional regulation and contagion, theory of mind, and empathic concern.

There are different types of empathy [16]:

- cognitive empathy refers to the ability to understand how someone else is feeling, but without necessarily sharing those emotions,
- emotional empathy refers to the ability to share the feelings of others and experience them as if they were our own,
- compassionate empathy is a combination of cognitive and emotional empathy. It involves understanding how someone else is feeling and then using that understanding to take action to help them.

While some people may naturally empathize with others, empathy can also be learned and developed over time.

### Empathy in design

Empathy is an important consideration in the design process, as it can help designers create products and experiences that are more accessible and inclusive for users with diverse needs and backgrounds.

One way to incorporate empathy into the design process is through user research. By conducting user research, designers can gather information about their users' needs, preferences, and experiences, and use this information to inform their design decisions. This can involve methods such as surveys, interviews, user testing, and observation.

Designers can also use empathy to put themselves in the shoes of their users and imagine what it would be like to use their products or experiences. This can involve practicing perspective-taking and imagining using the product from different points of view, such as those of users with different abilities, cultural backgrounds, or life experiences.

Empathy can also help designers to identify potential barriers to accessibility and inclusion, and to develop creative solutions to address them. By understanding the needs and experiences of their users, designers can create products and experiences that are more user-friendly, engaging, and effective.

### TEACHING EMPATHY

Empathetic designers possess the remarkable ability to consider the diverse needs of a broader target group,

demonstrating their deep understanding of human experiences. The capacity for empathy is a deeply personal trait, intricately influenced by cultural and educational factors, as well as one's own life journey. Expanding emotional empathy can be facilitated through a wide range of integration activities. For instance, engaging in interactions with individuals who are visually impaired can profoundly enhance one's comprehension of their emotions and requirements through observation, meaningful conversations, and more. Nurturing empathy involves equipping individuals with knowledge about compassion, acceptance, and embracing the mental and physical diversities among people. A powerful method of imparting such understanding is through simulations that replicate conditions of blindness, deafness, or limited mobility. Among the most renowned approaches for cultivating cognitive empathy are psychological interactions and strategic techniques that mirror real-world scenarios. Within this chapter, a variety of methods and approaches that can effectively foster empathy in communication, whether it is with end-users or within team dynamics will be explored.

### **Empathy in communication with the final user**

When designers communicate with users, it's vital to understand their needs, preferences, and experiences. Listening closely to their feedback and suggestions is key. Active listening involves giving someone your undivided attention and trying to see things from their perspective. This allows designers to better comprehend users' needs and concerns to develop more effective solutions.

Empathizing with users also helps communicate ideas and solutions in a way that resonates. Understanding users' emotional and cognitive experiences lets designers craft messages and communications that engage, mean more, and persuade. Empathy helps build trust and rapport between designers and users. Showing understanding and care about users' needs cultivates stronger relationships and partnerships, making products and experiences more user-friendly and effective [17].

There exist several specific approaches through which empathy may be incorporated into the interactions between those who design products and the final users.

#### **Open-ended questions**

Asking open-ended questions can be an incredibly effective and valuable strategy for designers to establish meaningful communication with users. By utilizing open-ended questions, designers create a welcoming

environment that encourages users to freely express their experiences, needs, and preferences. These questions are designed to elicit more than simple "yes" or "no" responses, allowing users to delve deeper into their thoughts and provide detailed insights. Through open-ended questions, designers can uncover rich and nuanced information that goes beyond surface-level understanding. This approach not only facilitates a deeper connection with users but also empowers designers to gain a comprehensive understanding of user perspectives, motivations, and aspirations. By actively listening and engaging users with open-ended questions, designers can acquire invaluable insights that drive the creation of user-centered solutions and enhance the overall user experience [18,19].

#### **Active listening**

Active listening is a crucial skill that designers should develop to enhance their communication with users. When designers practice active listening, they focus not only on the words being spoken but also on the underlying emotions, non-verbal cues, and subtle nuances in user communication. By attentively listening to users, designers can gain a deeper understanding of their needs, desires, and challenges. Active listening involves giving users undivided attention, maintaining eye contact, and providing verbal and non-verbal cues to show genuine interest and empathy. It also entails refraining from interrupting and allowing users to express themselves fully. By actively listening, designers create a safe and supportive space for users to share their thoughts and experiences, fostering trust and collaboration. Furthermore, this empathetic approach enables designers to identify insights and uncover user motivations that can inform the design process. Ultimately, incorporating active listening into their communication toolkit empowers designers to create solutions that truly resonate with users and address their unique requirements [20].

#### **Observation**

In addition to active listening, effective designers also practice empathy-driven observation to gain valuable insights into user behaviors and needs. By carefully observing users in their natural environments or during interactions with products or services, designers can uncover subtle details and patterns that may go unnoticed through traditional interviews or surveys alone. Empathy-driven observation involves keenly observing users' actions, body language, facial expressions



Figure 1. Facial expressions representing different emotions

(Figure 1), and other non-verbal cues to discern their emotions, frustrations, and preferences. This method allows designers to empathize with users on a deeper level, putting themselves in their shoes and gaining a firsthand understanding of their experiences. By immersing themselves in the user's context, designers can identify pain points, discover unmet needs, and generate innovative ideas for improving the user experience. Moreover, empathy-driven observation enables designers to uncover discrepancies between what users say and what they do, providing valuable insights for refining and iterating on design solutions. By embracing this observational approach, designers can truly empathize with users and create meaningful and impactful designs that address their real-life challenges.

#### Perspective-taking

Practicing perspective-taking is a vital skill that designers should develop to enhance their understanding of

users. Perspective-taking involves the ability to put oneself in someone else's place and genuinely see things from their point of view. By stepping outside their own frame of reference, designers can gain valuable insights into the thoughts, emotions, and motivations that drive user behavior. This empathetic approach allows designers to develop a deeper appreciation for the diverse perspectives, needs, and challenges of their users. When designers practice perspective-taking, they go beyond surface-level assumptions and actively seek to understand the world through the eyes of the user. They consider factors such as cultural background, personal experiences, and individual preferences that shape the user's unique viewpoint. This practice helps designers to design solutions that align with the user's values and resonate with their lived experiences. By immersing themselves in the user's perspective, designers can identify pain points, anticipate user requirements, and create designs that truly address their needs. It enables



**Figure 2.** Student during perspective-taking session: the task was to check the accessibility of the premises of one of the departments of the Technical University of Lodz – accessibility for people in wheelchairs

designers to make informed decisions and prioritize features or functionalities that are most meaningful to the users. Moreover, perspective-taking fosters empathy and humanizes the design process, ensuring that the end products or services are inclusive, accessible, and user-centered. By actively practicing perspective-taking, designers can bridge the gap between their own understanding and the experiences of their users. This empathetic mindset allows them to create designs that not only meet functional requirements but also provide meaningful and enriching experiences for the intended users [21]. An example of a perspective-taking session at Lodz University of Technology is presented in Figure 2.

### Persona

Using user personas, which are fictional representations of typical users based on thorough research and data, can greatly assist designers in creating more targeted and effective communication strategies. User personas serve as powerful tools that encapsulate the characteristics, goals, motivations, and pain points of specific user segments. By creating these personas, designers can develop a deeper understanding of their target audience and tailor their communication to resonate with their needs and preferences. User personas enable designers to humanize the design process by giving them a clear picture of who they are designing for. These personas go beyond generic demographics and delve into the psychological and behavioral aspects of users. By considering factors such as user goals, challenges, values, and

aspirations, designers can craft communication messages that are not only relevant but also emotionally engaging. When designers communicate with user personas in mind, they can use language, tone, and messaging styles that resonate with the specific user segment. This personalized approach creates a sense of empathy and connection, fostering trust and engagement with the target audience. Furthermore, user personas help designers make informed design decisions by providing a reference point for evaluating the impact of their designs on different user groups. By constantly referring to the personas throughout the design process, designers can ensure that their communication effectively addresses the unique needs and expectations of their intended users [22].

### Empathy map

Using empathy maps, which are visual tools that help designers understand users' emotions, thoughts, and behaviors, opens new avenues for gaining a deeper understanding of users' experiences. These powerful tools provide designers with a structured framework to explore and document key insights about users, enabling them to develop a more empathetic approach to design. Empathy maps are typically divided into sections that represent different aspects of the user's experience, such as what they see, hear, think, feel, and do. By visually mapping out these dimensions, designers can systematically capture and analyze the user's perspective, bringing their needs and desires to the forefront. Through empathy maps, designers can step into

the user's shoes and explore their emotional landscape, uncovering pain points, motivations, and desires that may influence their interactions with a product or service. By understanding users on a deeper level, designers can create experiences that resonate with their target audience, ultimately leading to higher user satisfaction and engagement. The visual nature of empathy maps helps designers communicate and share user insights with their team members or stakeholders effectively. It fosters a shared understanding of the user's journey, allowing for more collaborative decision-making and informed design choices. Moreover, empathy maps serve as a valuable reference point throughout the design process, reminding designers to continuously prioritize user needs and perspectives. By revisiting the empathy map, designers can evaluate the effectiveness of their design solutions and make necessary adjustments to ensure a user-centered approach [24]. An example of an empathy map is shown in Figure 3.

### Empathy in communication among the team

Empathy plays a crucial role in effective communication within a team. It involves understanding and sharing the feelings, thoughts, and perspectives of others. When team members communicate with empathy, it fosters trust, collaboration, and a positive working environment. Here are some key points to consider.

#### Active listening

Empathetic communication goes beyond mere hearing and involves active listening as its foundation. When practicing empathetic communication within a team, it is crucial for each team member to offer their undivided attention to the speaker. This means fully engaging in the listening process, demonstrating a genuine interest in what the speaker has to say.

One key aspect of active listening is maintaining eye contact. By establishing and maintaining eye contact, team members signal their attentiveness and respect for the speaker. It conveys a sense of presence and validates the speaker's words, fostering an environment of trust and openness.

Another essential element of empathetic communication is the ability to resist the urge to interrupt or formulate responses prematurely. Instead, team members should prioritize understanding the speaker's message before offering their own input. This requires practicing patience and restraint, allowing the speaker to express themselves fully without interruption. By doing

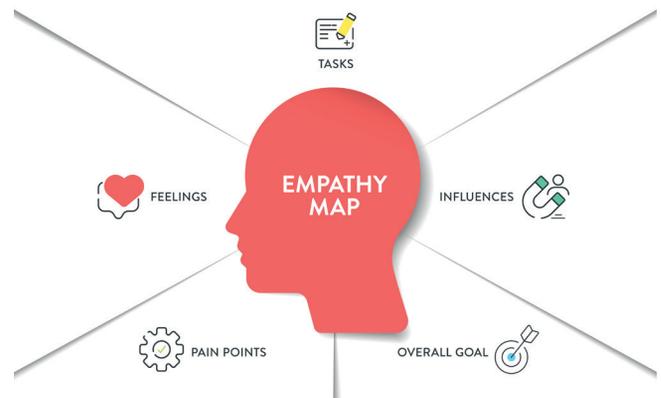


Figure 3. Empathy map template

so, team members demonstrate respect for the speaker's perspective and create a safe space for open and meaningful dialogue.

Additionally, active listening involves non-verbal cues such as nodding, smiling, or providing other forms of positive reinforcement. These subtle signals indicate to the speaker that their words are being heard and valued. Such non-verbal cues can help foster a sense of connection and encouragement, further enhancing the empathetic communication process within the team.

By cultivating active listening skills and embracing empathetic communication, team members can establish a supportive and collaborative environment. This approach allows for effective information sharing, encourages diverse perspectives, and nurtures a sense of belonging and psychological safety within the team. Ultimately, practicing empathetic communication enhances teamwork, promotes mutual understanding, and paves the way for more productive and meaningful collaborations.

#### Perspective-taking

Perspective-taking is a powerful tool for fostering empathy and understanding within a team. Encouraging team members to actively put themselves in others' shoes cultivates a sense of empathy, enabling them to consider different viewpoints, understand the emotions at play, and gain deeper insights into their colleagues' words and actions [25].

By promoting perspective-taking, team members are encouraged to step outside their own perspectives and consider the unique experiences, backgrounds, and motivations of their colleagues. This practice helps to break down barriers and create a more inclusive and collaborative work environment [26].

When engaging in perspective-taking, team members strive to understand not only what their colleagues are saying but also the underlying emotions and motivations behind their communication. This requires active listening, open-mindedness, and a genuine curiosity to explore different perspectives. By doing so, team members can develop a more comprehensive understanding of their colleagues' thoughts and feelings, leading to improved empathy and effective communication.

In addition to understanding others' perspectives, perspective-taking also involves suspending judgment and embracing a non-judgmental mindset. By setting aside preconceived notions or biases, team members create space for respectful and constructive dialogue. This allows for a more open exchange of ideas and encourages a diversity of thought within the team.

Encouraging perspective-taking within the team also helps to foster a culture of empathy and mutual support. When team members try to understand one another's perspectives, they are better equipped to collaborate effectively, resolve conflicts, and find creative solutions. It promotes a sense of trust and strengthens relationships, enhancing teamwork and overall team performance.

### Non-verbal cues

When engaging in communication, it is essential to pay close attention to non-verbal cues, which encompass body language, facial expressions, and tone of voice. These subtle cues can speak volumes, conveying a wealth of emotions and offering valuable insights into the speaker's state of mind. By actively observing and interpreting these non-verbal cues, you can gain a deeper understanding of the speaker's thoughts and feelings, enabling you to respond with empathy and sensitivity.

Body language serves as a powerful indicator of someone's emotional state and can reveal underlying sentiments that may not be expressed verbally. A person's posture, gestures, and movements can provide significant clues about their level of comfort, confidence, or distress. By attentively observing these non-verbal signals, you can better gauge the speaker's emotional response and adjust your own communication approach accordingly.

Facial expressions offer a window into a person's emotions, unveiling feelings of joy, sadness, frustration, or concern. The slightest change in someone's facial expression, such as a furrowed brow or a genuine smile, can convey a wealth of information about their current state of mind. By being attentive to these facial cues, you

can demonstrate your empathetic nature by acknowledging and responding to their emotional needs.

Tone of voice is another critical non-verbal cue that can greatly impact communication. The way someone speaks, including the pitch, volume, and rhythm of their voice, can communicate various emotions and attitudes. A soothing tone can provide comfort, while a harsh tone can indicate frustration or anger. By actively listening and discerning the speaker's tone of voice, you can adapt your own tone and response to ensure a compassionate and empathetic exchange.

When you respond empathetically to these non-verbal cues, it demonstrates your attentiveness and genuine concern for the speaker's feelings. By acknowledging and addressing their unspoken emotions, you create a safe and supportive space for open communication. This empathetic approach fosters trust, strengthens relationships, and cultivates a deeper connection with others.

### Validation

Validation is a fundamental aspect of empathy that emphasizes the importance of acknowledging and affirming others' emotions and experiences. Instead of dismissing or minimizing someone's concerns, genuine empathy involves expressing understanding and compassion. By validating their feelings, you create a safe and supportive space where individuals feel heard and understood.

When practicing empathy, it's essential to use validating language to convey your understanding. Phrases such as "I understand how you feel" or "That must be challenging" demonstrate empathy and communicate that you recognize the validity of their emotions. These expressions of support can help individuals feel acknowledged, valued, and less alone in their experiences.

Furthermore, validation involves actively listening to others without judgment. It means being fully present and attuned to their emotions, non-verbal cues, and underlying needs. By demonstrating genuine interest and attentiveness, you show that you are invested in understanding their perspective and providing the support they need.

Validation can also extend beyond verbal communication. Non-verbal cues such as nodding, maintaining eye contact, and offering comforting gestures can reinforce your empathy and validate the emotions being expressed. These non-verbal signals communicate your presence and support, creating an environment where individuals feel comfortable sharing their thoughts and feelings.

Additionally, validation involves refraining from offering unsolicited advice or attempting to solve the problem immediately. Instead, focus on validating the emotions and experiences of others without trying to fix or minimize their concerns. By doing so, you foster a sense of trust and create space for individuals to explore their feelings and find their own solutions if they choose to do so.

### **Emotional regulation**

Emotional regulation plays a vital role in fostering empathetic communication within a team. It involves team members being self-aware and actively managing their own emotions during interactions. By recognizing and controlling personal biases, prejudices, and emotional reactions, team members can create an environment conducive to empathetic understanding and effective communication.

To practice emotional regulation, team members should cultivate self-awareness by paying attention to their own emotional states and triggers. This involves reflecting on their own biases, preconceptions, and assumptions that may influence their perceptions and responses. By being mindful of these internal factors, team members can better navigate their emotions and prevent them from impeding empathetic understanding.

Furthermore, emotional regulation involves the ability to respond to challenging situations with empathy and understanding rather than reacting impulsively or defensively. It requires pausing to reflect on the emotions that arise and consciously choosing how to respond. This may involve taking deep breaths, using calming techniques, or seeking perspective from others before formulating a thoughtful and empathetic response.

It's important for team members to recognize that emotional regulation is an ongoing process that requires continuous self-reflection and growth. By engaging in practices such as mindfulness, self-care, and seeking feedback from others, team members can strengthen their emotional regulation skills and enhance their ability to communicate empathetically.

Moreover, fostering an environment of emotional safety within the team supports effective emotional regulation. When team members feel safe expressing their emotions without fear of judgment or reprisal, they are more likely to regulate their emotions effectively. Building trust and psychological safety through open communication and supportive interactions encourages emotional honesty and vulnerability.

By practicing emotional regulation, team members create a foundation for empathetic communication within the team. They develop the ability to set aside personal biases and prejudices, enabling them to genuinely understand and empathize with others' perspectives. This enhances collaboration, strengthens relationships, and promotes a positive team culture based on mutual respect and understanding.

### **Open and honest communication**

Open and honest communication is a cornerstone of effective teamwork and empathetic collaboration. By fostering an environment where individuals feel safe to express their thoughts, concerns, and emotions without fear of judgment or reprisal, teams can cultivate trust, mutual respect, and open dialogue.

Creating a safe space for open communication involves establishing clear expectations and norms within the team. Encourage team members to actively listen to one another, value diverse perspectives, and refrain from personal attacks or defensiveness. Emphasize that all ideas and contributions are valued and that disagreements can be addressed constructively.

To promote open and honest communication, team leaders and members should lead by example. Demonstrate active listening by giving your full attention, maintaining eye contact, and showing genuine interest in what others have to say. Encourage and validate different viewpoints, even if they differ from your own. This creates an atmosphere where individuals feel heard and understood, fostering a sense of psychological safety.

In addition, establish regular check-ins or team meetings where individuals have dedicated time to share their thoughts, concerns, and emotions. This can be done through open forums, one-on-one conversations, or anonymous feedback channels, depending on the team's dynamics and preferences. Ensure that everyone has an equal opportunity to contribute and that their input is valued.

When conflicts arise, encourage open and respectful dialogue to address them. Provide a platform for individuals to express their concerns, actively listen to all perspectives, and work collaboratively towards resolution. Emphasize the importance of finding common ground and seeking win-win solutions that consider the needs and interests of all team members.

Furthermore, it is crucial to establish confidentiality and trust within the team. Assure team members that their conversations and expressed vulnerabilities will be

kept confidential unless there is a need to escalate or address specific issues. This creates a sense of psychological safety, allowing individuals to share their thoughts and emotions more freely.

By promoting open and honest communication, teams can break down barriers, foster empathy, and enhance their problem-solving capabilities. It encourages a culture of transparency, collaboration, and mutual understanding. Team members feel empowered to express their true thoughts and emotions, leading to stronger relationships, improved decision-making, and a more harmonious and productive work environment.

### **Conflict resolution**

Empathy plays a vital role in resolving conflicts within a team. Encourage team members to listen empathetically to conflicting perspectives, seek common ground, and find mutually beneficial solutions. Additionally, an important skill is the ability to seek compromise, ensuring that active users are aware of their influence on the final shape of the project. This fosters increased engagement in current and future design activities, while also stimulating creativity and a sense of collective action. By finding middle ground and involving users in decision-making, teams can create a collaborative environment that encourages participation and generates a stronger sense of ownership and satisfaction among team members and users alike.

### **METHODS TO MEASURE EMPATHY**

Empathy is a multifaceted and complex phenomenon, and everyone can have it in different aspects and levels of development. There are several studies that address the promotion of empathy, often more oriented to the healthcare area (where disease or injury debilitated individuals require special attention), but whose methods and theories are fully transversal to other areas. In terms of teaching approach, in Gerdes et al. [27] a framework is proposed for teaching empathy that is rooted in social cognitive neuroscience and social justice. In particular, the authors explore the process of neural path-way development that determines the affective empathic responses of each individual and how to develop and maintain cognitive empathic abilities. In Thangarasu et al. [28] it is argued that empathy can be taught through role modeling and real-time feedback from patients. In a meta-analysis performed by Teding van Berkhout and Malouff [29] it is found that empathy training has

demonstrated effectiveness in enhancing empathic abilities, and several factors have been identified as contributors to the success of these interventions. Firstly, it is important to directly target the population that should be intervened. Secondly, compensating trainees for their participation has been found to increase motivation and engagement, leading to more fruitful outcomes. Additionally, utilizing empathy measures that specifically assess the understanding of others' emotions, the experience of those emotions, or the accurate identification and commentary on emotions has proven to be valuable in evaluating the effectiveness of training programs. Lastly, employing objective measures, rather than relying solely on self-report measures, provides a more reliable and unbiased assessment of empathic progress.

Considering the different learning theories (behaviorist, cognitive, constructivist, social and experiential, among others Gandhi and Mukherji [30]), considering the different learning styles (visual, auditory, kinesthetic and reading/writing) and without forgetting the individual perspective, where environmental, cognitive and emotional influences have their role, one can assert that multimodal immersive experiences are by far the most effective way of promoting empathy. Hence for an effective promotion of empathy the stimuli provided must be diverse and intense. Sweeney and Baker [31] and Berliner and Masterson [32] discuss the importance of empathy in patient-centered care and suggest that video-based teaching is educational interventions and mentioned that, when these occur at early childhood, they can be especially effective. Roberts et al. [33] found that immersive learning scenarios can enhance empathy in healthcare students. Crandall and Marion [34] emphasizes the importance of identifying attitudes towards empathy and suggests that empathy can be taught and assessed as a cognitive skill.

As learning, research suggests that also empathy is influenced by various factors, including cultural and social contexts, personal experiences, and individual differences in personality traits. Personality profiles obtained through assessments like DISC (dominance, influence, steadiness and conscientiousness) [35] or Big Five personality traits [36] can provide insights into certain personality traits and tendencies that can be related to empathy. While these assessments primarily focus on broader personality dimensions rather than specifically targeting empathy, they can still offer valuable information about an individual's potential

empathic tendencies. For example, Costa et al. [37] and Lourinho and Severo [38], found positive correlations between empathy and agreeableness and openness to experience, and Lourinho and Severo [38] found positive correlations between empathy and neuroticism, extraversion, and conscientiousness. These findings come to support the idea that people with high agreeableness are often described as warm, compassionate, and considerate, which can contribute to their ability to empathize with others. On the other hand, individuals who score higher in openness to experience tend to be more open-minded, imaginative, and receptive to new ideas and perspectives. This trait can facilitate cognitive empathy, enabling individuals to better understand and appreciate diverse emotional experiences.

Konrath et al. [39] the use of the *Single Item Trait Empathy Scale* (SITES) which is a brief and simplified measure designed to assess an individual's trait empathy using a single-item question. The scale aims to provide a quick and convenient way to capture an individual's general level of empathy. It consists of a single question that asks respondents to rate themselves on a 7-point Likert scale, typically ranging from "strongly disagree" to "strongly agree." The question typically takes the following form: "To what extent do you agree or disagree with the statement: "I am a very empathetic person?"". The scale is derived from the understanding that empathy is a multi-faceted construct, encompassing cognitive and affective components. However, the SITES simplifies the measurement by focusing on the overall trait of empathy rather than assessing specific dimensions of empathy in detail. To use the SITES, individuals are asked to indicate their level of agreement or disagreement with the statement provided. They select the response that best reflects their self-perceived empathetic nature. The scale is self-report in nature, relying on individuals' subjective assessment of their own empathy. Despite the advantages of this approach, it may not capture the complexity and nuances of empathy as comprehensively as more extensive measures.

Interception, considered to be an important factor in emotional response, was found to also influence empathy. Fukushima et al. [40] that the heartbeat-evoked potential (HEP), a surface EEG pattern, are positively correlated with empathy patterns. In fact, psychophysiological markers are powerful tools in measuring empathy, providing assertive and objective insights into the physiological responses associated with empathic experiences. These markers unveil the intricacies of

human emotions and empathic connections, leaving no room for doubt. Heart rate variability (HRV) lays bare the rhythms of empathy, exposing the very pulse of our empathic engagement. Skin conductance response (SCR) boldly reveals the intensity of our emotional arousal, leaving no room for ambiguity. Facial electromyography (EMG) captures the unspoken language of empathy, asserting the undeniable truth etched upon our expressive faces. Event-related potentials (ERPs) illuminate the neural symphony behind empathy, leaving no doubt about the intricate workings of our empathic processing. Together, these unwavering psychophysiological markers paint an indomitable picture of empathy, bridging the chasm between subjectivity and objectivity.

Research also suggests that EEG can be used to estimate empathy. Osaka [41] found that EEG changes during emotional scenes can indicate empathic understanding. By using power map and spectrogram analyses of EEG, alpha bands at the occipital region were observed to be correlated with emotionally impressed states and it seemed that changes indicated the objective expression of empathic understanding. Kim et al. [42] computational methods for EEG-based emotional state estimation, including emotion-related feature extraction and classification. Yoon and Chung [43] a probabilistic classifier based on Bayes' theorem and a supervised learning using a perceptron convergence algorithm to estimate emotions from EEG signals. By analyzing EEG data, researchers can identify specific brainwave patterns and event-related potentials (ERPs) that are related to empathic responses. For example, the ERP component known as the "empathy related P300" has been found to be associated with cognitive and emotional processes involved in empathy [44], EEG can provide insights into the timing and localization of neural activity during empathic experiences. It can help identify brain regions and networks involved in empathy, such as the prefrontal cortex, anterior cingulate cortex, and mirror neuron system. Additionally, EEG-based hyper scanning techniques [1] the simultaneous recording of brain activity from multiple individuals, allowing for the examination of neural synchrony and inter-brain connectivity during empathy. While EEG provides valuable information about the neural correlates of empathy, it is important to consider that it reflects the overall brain activity and may not capture the full complexity of empathic processes. Combining EEG with other measures, such as behavioral assessments

or self-report measures, can provide a more comprehensive understanding of empathy.

### UNIVERSAL DESIGN EDUCATION CHALLENGES

Learning universal design can come with a few challenges. Here are provided the main common issues to be addressed:

1. Limited prior exposure: students may be limited to universal design concepts before entering their engineering programs. Building a foundation of knowledge and awareness becomes crucial at the student level.
2. Limited professional experience: unlike experienced engineers, students may have yet to have practical experience in engineering projects that incorporate universal design principles. Providing them with opportunities for hands-on projects or internships can help bridge this gap.
3. Limited interdisciplinary exposure: students may have had little exposure to interdisciplinary collaboration during their education. Encouraging multidisciplinary projects, workshops, or seminars can help students understand the value of working with professionals from other fields.
4. Changing mindsets: students might come into their engineering programs with pre-existing biases or misconceptions about disability or universal design. It becomes important to address these attitudes early on and cultivate a mindset of empathy and inclusivity.
5. Limited resources: students may need more resources, such as access to assistive technologies, funding for inclusive design projects, or access to specialized training. Providing resources, mentorship, and support can help students overcome these limitations.

To address these student challenges, educational institutions can integrate universal design principles into their curriculum, offer elective courses or workshops focused on accessibility and inclusivity, provide opportunities for interdisciplinary projects, promote a culture of inclusivity and empathy, and ensure access to necessary resources for hands-on learning experiences.

When it comes to teaching universal design, teachers themselves can encounter certain challenges. Here are provided key ones:

1. Knowledge and training: teachers need to possess a solid understanding of universal design principles, accessibility guidelines, inclusive pedagogical

practices, and assistive technologies. However, not all teachers may have received formal training in these areas, which can make it challenging to effectively teach universal design concepts.

2. Curriculum development: developing a curriculum that effectively integrates universal design can be complex. It requires identifying appropriate learning objectives, designing instructional materials and activities that promote inclusivity, and incorporating diverse perspectives and examples. Teachers may face challenges in adapting existing curricula or creating new ones that align with universal design principles.
3. Limited resources: teachers may face constraints in terms of resources, such as accessible teaching materials, assistive technologies, or specialized training. Lack of access to these resources can make it challenging to implement universal design practices effectively.
4. Pedagogical approach: teaching universal design requires adopting an inclusive pedagogical approach that accommodates diverse learning styles and needs. Teachers may need to adapt their instructional methods, assessment strategies, and classroom environments to ensure inclusivity, which can be a challenging task.
5. Time constraints: teachers often face time constraints within the curriculum to cover various topics. Integrating universal design can require additional time and effort, which may be a challenge given the existing demands of the educational system.

To overcome these challenges, teachers can seek professional development opportunities to enhance their knowledge and skills related to universal design. They can collaborate with experts, engage in interdisciplinary discussions, and share best practices with their colleagues. It's also important for educational institutions to provide teachers with the necessary resources, support, and professional development opportunities to effectively teach universal design principles.

### CONCLUSIONS

This article explores the relevance of universal design and empathic design in education, specifically focusing on their application in creating inclusive and user-centered design solutions. Universal design aims to develop products, environments, and systems that are accessible and usable for individuals with diverse abilities, while

empathy involves understanding and sharing the feelings of others.

The article highlights the importance of teaching empathy to engineers, as it equips them with the skills to gain a deeper understanding of user needs and perspectives. By cultivating empathy, engineers can enhance their ability to design solutions that cater to a wide range of users, considering their unique abilities and requirements.

In order to foster empathy in engineering practice, the article explores effective communication techniques. These techniques include asking open-ended questions to encourage users to express their needs, engaging in active listening to truly understand their experiences, employing observation to gain insights into their behaviors and interactions, and practicing perspective-taking to view design challenges from the user's point of view. By employing these communication strategies, engineers can enhance their empathic engagement with users and develop more inclusive designs.

Additionally, the article delves into methods for measuring empathy in design. Measuring empathy allows engineers to assess the effectiveness of their empathic design approaches and make informed decisions based on user feedback and experiences. These measurement techniques help engineers validate the impact of their designs and continuously improve their empathic design processes.

Moreover, the article acknowledges the challenges that students, teachers, and university authorities may encounter in implementing courses that integrate universal design and empathic design principles. These challenges can range from limited awareness and resources to the need for curriculum adaptations and interdisciplinary collaboration. By acknowledging and addressing these challenges, educational institutions can foster an environment that supports the effective integration of universal design and empathy into engineering education.

Overall, this article emphasizes the importance of universal design and empathy in education, particularly in the field of engineering. By teaching empathy and incorporating effective communication techniques, engineers can design products and systems that promote inclusivity and cater to the diverse needs of users. Furthermore, by recognizing and addressing the challenges in implementing universal design and empathic design courses, educational institutions can pave the way for a more accessible and inclusive future in engineering and beyond.

#### Author contributions

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**Statistical analysis:** Dorota Kamińska, Grzegorz Zwoliński

**Interpretation of results:** Luis Pinto-Coelho, Rui Raposo

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