Co-funded by
the European Union

ErgoArt

2023-1-SI01-KA220-HED-000166987
(Application form ID: KA220-HED-EF096731)

TRAINING MATERIALS

Case studies with different innovative and interactive teaching tools

Project Title
Ergonomic workplace design for workers with disabilities and their long-term employment

Project Acronym: **ERGOART**

November 2025
All ErgoArt partners

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CMEPIUS

Case studies with different innovative and interactive teaching tools

1. Sensors suit for motion capture

1.1 Motion capture systems

For advanced workplace design and ergonomics, sensor suits are used to capture human movements with high precision. These systems collect data on body positions, acceleration, angular velocity, and spatial orientation, enabling detailed motion analysis. The collected data are then processed using specialized software, such as Siemens Jack, Process Simulate from Siemens PLM Software, or others, which allow 3D visualization of movements and assessment of ergonomic loads.

Such analyses enable optimization of workplace layout, improvement of workflow, prevention of musculoskeletal disorders, and increased productivity. The use of motion capture systems reduces subjectivity in ergonomic evaluations, allows analysis of complex and repetitive movements, and enables testing of new work processes and equipment before actual implementation.

1.2 Xsens suit

Xsens Technologies specializes in 3D motion capture, wearable, and inertial sensors using advanced MEMS technology. Their compact, lightweight sensors integrate accelerometers, gyroscopes, and magnetometers to measure acceleration, angular velocity, and spatial orientation. With precise algorithms, these sensors enable accurate 3D motion reconstruction.

Xsens solutions are used in industries like animation, biomechanics, and medicine. They aid in capturing human motion for digital characters, analysing gait and posture, enhancing athletic performance, and supporting rehabilitation and movement assessment.

For our research, we utilized the MVN Awinda system, which includes (Fig. 1):

- 17 wireless motion trackers,
- Awinda station,
- 2 Awinda chargers,
- full body suit components (shirt, headband, foot pads, gloves)
- segmometer.

Fig. 1. Xsens equipment for gathering body movement data

Motion capture sensors are mounted on a Lycra suit with additional straps to ensure stable attachment to the body and minimize skin motion errors. The motion trackers (MTw) measure various physical parameters: 3D angular velocity using gyroscopes, 3D acceleration using accelerometers, the 3D Earth magnetic field using magnetometers, and atmospheric pressure using barometers. The collected data are then processed using Xsens algorithms, which provide accurate drift-free 3D orientation, crucial for reliable motion reconstruction. Each sensor is powered by a LiPo battery, allowing up to six hours of continuous operation or ninety hours in sleep mode, providing flexibility for longer research or work sessions. This system enables objective data collection on human movements, which is essential for ergonomic analyses, workplace optimization, and the prevention of musculoskeletal disorders.

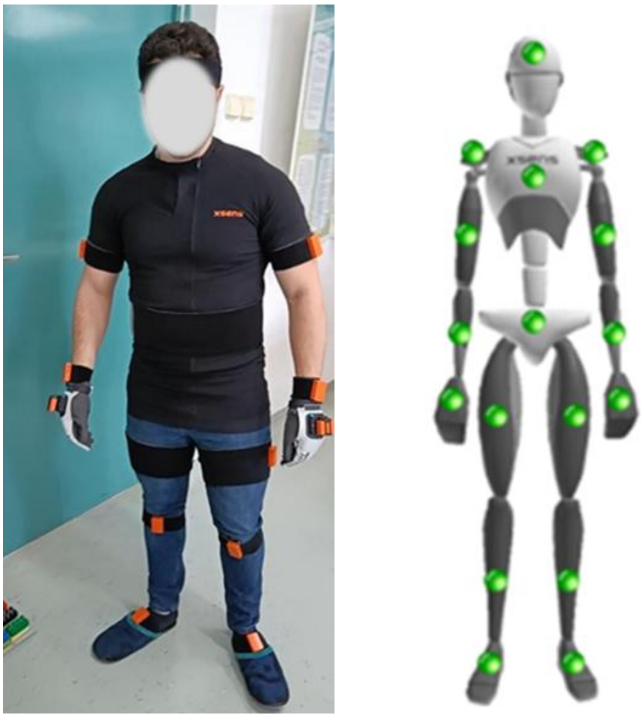


Fig. 2. Sensor’s position

Calibration

The purpose of subject calibration is to determine the physical dimensions of the tracked person and the precise orientation of the sensors relative to the corresponding body segments.

Calibration is performed in poses like N or T (Fig. 3) to align sensors with body segments, ensuring accurate measurements. Data is transmitted at 60 Hz, suitable for dynamic but not highly dynamic movements.

1. Scaling

   The dimensions are estimated using a general scaling model that takes into account the input data provided by the subject.

2. Sensor-to-segment Calibration

   For an accurate assessment of body segment kinematics, it is important to know the position and orientation of the sensors relative to each segment. Calibration is performed in poses such as N or T (Fig. 3), which ensures proper alignment of the sensors with the body segments and provides accurate measurements. Since direct measurements of this alignment are not possible, a reference pose is used, in which the segment orientations are assumed to be known, allowing reliable determination of their position and orientation. Correct execution of the static pose is crucial, as it ensures the accuracy of the overall calibration. This method is also resistant to the effects of magnetic disturbances.

3. Axes Definition

   Once the sensor-to-segment calibration is completed, the subject should assume a standing N-pose facing the forward direction of the measurement area. This procedure establishes the forward axis as well as the origin of the local coordinate system.

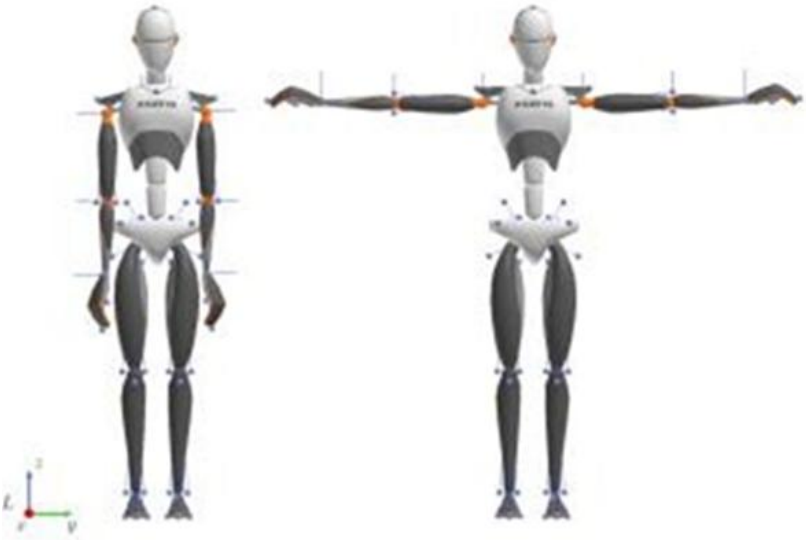


Fig. 3. Xsens avatar: N-pose and T-pose

Data Processing

MVN Analyze software was used to record and process the data, combining inputs from individual motion trackers with a biomechanical model of the human body, consisting of 23 segments, to obtain precise segment positions and orientations. The software allows for real-time data viewing; however, for the purposes of this study, offline analysis was used, enabling detailed playback and processing of the recorded data.

Motion tracking and limitations

In this study, the biomechanical model comprises 23 body segments: head, neck*, shoulders, upper arms, lower arms, hands, pelvis, vertebrae (L5*, L3*, T12*, T8), upper legs, lower legs, feet, and toes*. Segments marked with * do not have a dedicated sensor, so their movement is estimated based on the data from connected segments and the biomechanical model. Additionally, corrections are applied to account for the fact that the sensors are not fully firmly attached to the body, enabling accurate, drift-free determination of the relative position and orientation of all body segments and ensuring reliable motion tracking.

1.3 Process Simulate

Process Simulate is a software application developed by Siemens Digital Industries Software for simulating and optimizing manufacturing processes in industrial settings. It provides a comprehensive platform for designing, testing, and improving production systems, from factory layouts to individual operations, helping to identify bottlenecks, enhance workflow efficiency, and anticipate potential issues before implementation.

The program allows users to create and simulate complete manufacturing systems, including digital models of factories, production lines, work cells, equipment, robots, and operators, along with all associated processes. Through simulation, users can assess system performance, optimize workflows, reduce cycle times, identify bottlenecks, and evaluate the effects of design changes or varying production conditions.

Key Features:

- Manufacturing Systems Modeling: An intuitive interface to develop digital representations of entire production systems, including factories, production lines, workstations, equipment, and tooling.
- Process Simulation: Virtual execution of planned production processes to evaluate efficiency, optimize workflows, and reduce cycle times.
- Resource Analysis: Assessment of labor, time, and material requirements to optimize resource utilization and identify potential production constraints.
- Ergonomic Validation: Tools for analyzing workstation ergonomics and operator tasks, helping to identify health and safety risks and improve worker comfort and productivity.
- System Integration: Connection with other design and simulation tools as well as real-time production control systems to enable seamless data exchange and collaboration.

For our project, ergonomics validation will be performed, specifically using the OWAS method. The program allowed input of worker movements and positions, facilitating detailed ergonomic studies such as RULA, NIOSH, or OWAS. The OWAS method was chosen based on its suitability for our research objectives.

1.4 Case studies environment

Three case studies were performed for testing with the use of Xsens sensors suit: one for men, one for women, and a comparative study to assess the motor abilities of individuals with disabilities against a control group of individuals without limitations. For the case study demonstration, a simple polygon was designed, using Process Simulate software, containing the following tasks (Fig. 4 and 5):

- Walking: Walking along a straight path of approximately 6 meters
- Obstacle: Walking over 3 meters with 3 obstacles
- Walking backwards: walking 3 + 2 meters backwards
- Squat: squatting position
- Arm raised: position with arms raised
- Sitting: Sitting position
- T-posture: arms in T-position and one leg raised for 30 seconds

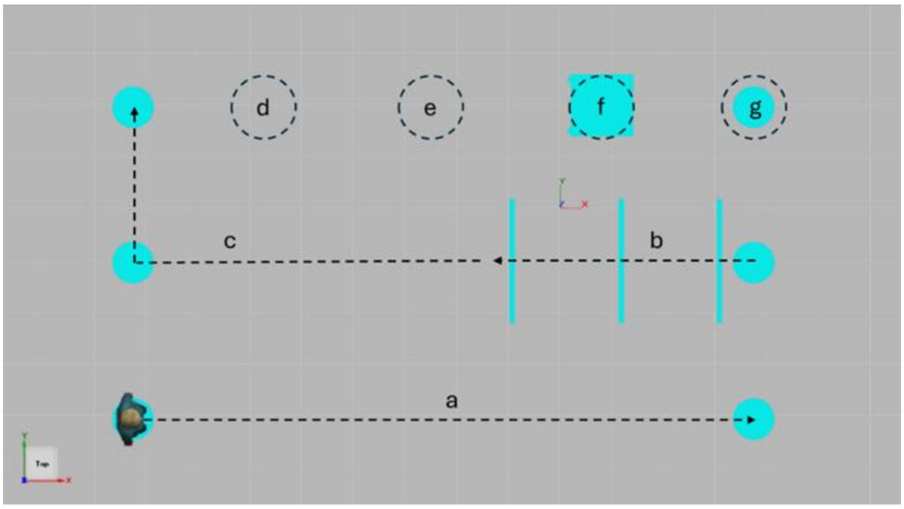
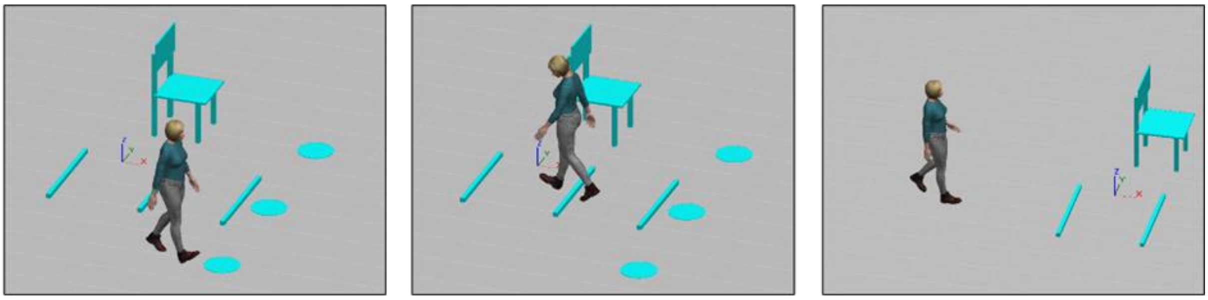
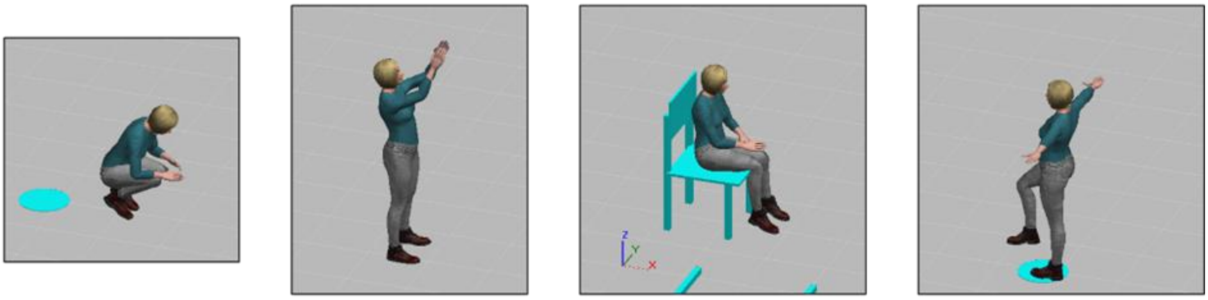


Fig. 4: Polygon circuit



Walking Obstacles Backward



Squat Arms raise Sit T-pose

Fig. 5: Simulated steps of the 'polygon circuit'.

A total of 62 participants completed the test course, with 6 measurements identified as invalid. These invalid measurements were primarily the result of data transfer errors and, to a greater extent, insufficient calibration of the measuring equipment, and were therefore excluded from further analysis.

Consequently, 56 valid measurements were considered for analysis, comprising 19 female and 37 male participants. Special attention was also given to participants with mobility limitations, who were classified into three categories:

- partial mobility impairments,
- more severe mobility impairments,
- physical injuries (for example, one participant was missing a toe).

In total, 10 participants with various types of limitations were included in the study. This ensured a representative sample that allows for a meaningful comparison of results between participants without limitations and those with different degrees of mobility or physical impairments.

1.5 Educational Use of Motion Capture Technologies and Ergonomic Simulation Tools

The presented content offers a comprehensive overview of modern motion capture technologies, sensor-based biomechanical analysis, and digital human modelling tools, providing valuable educational material for students in engineering, ergonomics, biomechanics, occupational safety, and industrial design. By exploring systems such as the Xsens MVN Awinda suit and Siemens Process Simulate, students gain insight into how human movement can be objectively recorded, analysed, and integrated into virtual simulations for workplace design and ergonomic assessment.

Through detailed descriptions of sensor types, calibration procedures, biomechanical modelling, and data processing workflows, students can learn how motion capture systems function—from the measurement of acceleration, angular velocity, and magnetic fields to the reconstruction of 3D human motion using advanced algorithms. This knowledge helps students understand the principles behind wearable sensor technology, human–machine interaction, and the challenges associated with capturing accurate kinematic data.

The integration of motion data with Process Simulate software demonstrates practical applications in digital manufacturing environments. Students can explore how virtual production systems are built, how workflows are optimised, and how ergonomic assessment tools such as OWAS, RULA, or NIOSH can be applied to evaluate worker posture and identify potential musculoskeletal risks. This supports the development of critical skills related to process analysis, workplace design, and occupational health.

The case studies included in the content—featuring male, female, and mobility-impaired participants—provide a realistic context for understanding human variability and the importance of inclusive design.

Presented technology can be used for laboratory exercises, project work, practical demonstrations, or interdisciplinary teaching. It offers students a valuable opportunity to apply theoretical knowledge in real-world scenarios, develop analytical and technical skills, and gain hands-on experience with advanced tools used in modern industry and research.

2. Age simulation suit GERT

2.1. Background

In the face of ongoing demographic changes and an ageing society, universal design has become one of the key challenges for contemporary engineering, architecture, and ergonomics. The growing participation of older people and individuals with various types of disabilities in social and professional life requires the creation of spaces, products, and services that are accessible to the widest possible range of users, regardless of age or level of ability.

Traditional methods of engineering education, such as lectures, laboratory classes, design projects, or professional internships, provide solid theoretical and technical foundations. However, they are often insufficient in terms of developing design sensitivity and a genuine understanding of the real needs of users with reduced functional abilities. For this reason, it is necessary to complement the educational process with active, experiential teaching methods that allow students to directly and physically experience functional limitations.

Within the ERGOART project, GERT age simulation suits were introduced as such an innovative tool. They enable realistic, hands-on experience of limitations associated with ageing and various forms of disability. Their application supports education in ergonomics, universal design, and the social responsibility of engineers and designers.

Fig. 2.1. GERT age simulation suit used to replicate age-related functional limitations. Source: manufacturer’s materials – symulator-starosci.com; produktundprojekt.de.

2.2. Tool description and functionality of the GERT simulator

GERT (Gerontology Suit) is a modular simulation system designed to replicate physical and sensory limitations typical of older adults. The system consists of wearable components that can be used individually or in various configurations, depending on the educational objectives.

The GERT suit enables simulation of, among others:

- reduced muscle strength in the upper and lower limbs,
- limited joint mobility,
- impaired balance and gait stability,
- decreased motor coordination,
- visual impairments (e.g. cataracts, reduced field of vision),
- hearing impairments,
- reduced grip precision and tactile sensitivity.

FIg.2.2. GERT simulation glasses used to replicate age-related visual impairments.
Source:produktundprojekt.de.

The modular design of the GERT simulator allows for gradual adjustment of the level of simulated limitations and adaptation to specific usage scenarios. This makes it possible to recreate both typical age-related difficulties and functional limitations similar to those experienced by people with permanent or temporary disabilities.

2.3. Educational application – student workshops (case study)

As a case study within the ERGOART project, educational workshops were conducted with students of technical and design-oriented study programmes using GERT simulation suits. The aim of the workshops was to develop design competencies in the field of universal design through direct experience of functional limitations.

Workshop participants analysed the accessibility of selected areas of the university building, including circulation routes, entrances, staircases, elevators, sanitary facilities, and teaching spaces. The simulation enabled students to adopt the perspective of users with reduced mobility, visual, or auditory abilities, allowing them to identify barriers that had previously gone unnoticed from the perspective of fully able-bodied users.

Fig.2.3. Practical assessment of door accessibility using the GERT age simulation suit during student workshops.

2.4. Workshop tasks using the GERT simulator

The workshops using GERT age simulation suits were designed as a set of practical tasks enabling students to directly experience functional limitations and to analyse the accessibility of the built environment from the perspective of users with reduced abilities. The tasks were carried out in small groups, which facilitated discussion, exchange of observations, and design-oriented reflection.

Task 1. Analysis of circulation routes: Participants, equipped with GERT simulation suits, moved along designated circulation routes within the university building (corridors, staircases, ramps, elevators). The objective of the task was to identify barriers hindering safe and comfortable movement, such as insufficient passage widths, lack of handrails, slippery surfaces, unclear signage, or excessive ramp inclinations.

Task 2. Assessment of entrances and doors: Students analysed the accessibility of main and secondary building entrances as well as internal doors, paying attention to the force required to open them, the height and ergonomics of door handles, the opening time of automatic doors, and the visual contrast of door leaves. The simulation allowed for an assessment of the difficulties encountered by older people and users with reduced upper-limb functionality.

Task 3. Use of functional spaces: The next stage involved using selected functional spaces, such as classrooms, sanitary facilities, service points, and relaxation areas. Students assessed the possibility of independently performing basic activities, including taking a seat, using sanitary equipment, operating light switches, or reading information boards. The analysis also included an evaluation of the clarity of visual and acoustic information.

Task 4. Spatial orientation and sensory perception: Using elements of the GERT simulator that restrict vision and hearing, participants performed tasks related to spatial orientation, locating designated places, and interpreting visual and auditory information. This task enabled the evaluation of the effectiveness of visual information systems, colour contrast, lighting conditions, and acoustic signals.

Task 5. Documentation of barriers and design solution proposals: Each group documented the identified barriers and difficulties in the form of notes, sketches, and photographs. Based on this documentation, students developed design solution proposals in accordance with universal design principles. These solutions included both architectural modifications and organizational or informational improvements.

Task 6. Reflection and group discussion: The workshops concluded with a moderated discussion during which participants shared their experiences and reflections resulting from the simulation. Particular emphasis was placed on discussing the differences between the designer's perspective and the user's perspective, as well as on the role of empathy and social responsibility in the design process.

The implementation of the above tasks enabled students not only to apply theoretical knowledge in practice but also to develop social and design-related competencies. Workshops using the GERT simulator effectively supported the development of design awareness and the ability to identify and eliminate environmental barriers, which constitutes an important element of education in ergonomics and universal design.

Fig. 2.4. Evaluation of campus accessibility from the perspective of a user with reduced mobility using the GERT simulator.

Table 2.1 . Overview of workshop tasks using the GERT age simulation suit.

No.	Workshop task	Educational objective	Scope of analysis / learning outcome
1	Analysis of circulation routes	Experiencing mobility limitations	Identification of movement barriers (stairs, ramps, handrails, surfaces)
2	Assessment of entrances and doors	Understanding motor and strength-related difficulties	Evaluation of door ergonomics, handles, and automatic door systems
3	Use of functional spaces	Analysis of user independence	Assessment of accessibility of classrooms, sanitary facilities, service areas
4	Spatial orientation and sensory perception	Experiencing visual and auditory limitations	Evaluation of signage clarity, lighting, and acoustic signals
5	Documentation of barriers	Development of analytical skills	Identification and classification of architectural and ergonomic barriers
6	Design solution proposals	Application of universal design principles	Development of architectural and organizational improvements
7	Reflection and group discussion	Development of empathy and social competencies	Awareness of designers' responsibility towards users

2.5. Case study results and impact on the design process

The experiences gained during the workshops had a direct impact on the quality of the projects developed by students. Comparative analysis showed that after using the GERT simulators, participants more frequently identified architectural and ergonomic barriers and proposed solutions consistent with universal design principles.

The student projects increasingly addressed the needs of users with diverse abilities, including older adults, people with visual or hearing impairments, individuals with permanent disabilities (e.g. cerebral palsy), and users with temporary disabilities, such as post-accident injuries or lower-limb fractures. The simulation enabled a deeper understanding of the relationship between design decisions and the actual comfort and safety of users.

2.6. Educational value and relevance for the ERGOART project

The use of GERT age simulation suits makes it possible to evoke empathic engagement among participants in the educational process, which is a key element in the development of social competencies of future engineers and designers. Direct experience of functional limitations encourages reflection on designers’ responsibility and the need to consider the diverse needs of users.

The results of the workshops confirm that GERT simulators constitute an innovative and effective educational tool supporting the objectives of the ERGOART project. Integrating such tools into the educational process contributes to improving project quality, promoting universal design, and fostering the creation of safe, accessible, and inclusive working and learning environments.

3. Using an evacuation chair for inclusive safety education

3.1. Background

Ensuring the safe evacuation of people with disabilities and individuals with reduced mobility is a crucial aspect of universal design and safety management in public buildings. In emergency situations such as fire, technical failure, or power outages, standard evacuation routes—particularly staircases—may prevent independent evacuation of wheelchair users or people with other mobility limitations.

In practice, evacuation chairs are used as a response to this challenge. These devices enable the safe transport of individuals with reduced mobility down staircases with minimal physical effort required from the operator. From an educational perspective, evacuation chairs offer significant didactic potential, as they integrate issues related to ergonomics, safety engineering, universal design, and the social responsibility of designers.

Within the ERGOART project, the evacuation chair was introduced as an innovative and interactive educational tool, complementing traditional teaching methods with hands-on, experience-based learning.

3.2. Tool description and functionality

An evacuation chair is a specialised device designed for the safe transportation of people with reduced mobility down staircases during emergency situations. Its construction typically includes a system of safety belts, ergonomic handles for the operator, and a sliding or tracked mechanism that allows controlled descent along stairs.

From the perspective of ergonomics and inclusive design, both the technical parameters of the evacuation chair and the spatial conditions required for its use are of key importance. These include staircase width, step geometry, the presence of landings, handrails, and potential architectural obstacles. Analysing these factors enables an assessment of the real feasibility of evacuation procedures in existing buildings.

Fig. 3.1. Evacuation chair used for the safe transport of people with reduced mobility during emergency situations.

3.3. Educational application – student workshops

The evacuation chair was incorporated into practical workshops conducted as part of the ERGOART project, with the aim of developing students' competencies in designing safe and accessible built environments. The workshops were organised in small groups and had a strongly practical character.

During the sessions, participants were introduced to the construction of the evacuation chair, its operating principles, and procedures for preparing the device for use. Students practiced safe evacuation scenarios, including the controlled transport of a person with reduced mobility down staircases, while considering the roles and responsibilities of assisting personnel and emergency responders.

3.4. Case study results

As a case study, a simulated evacuation of a person with reduced mobility from an upper floor of a university building was conducted using an evacuation chair. Students assumed the roles of device operators and observers, analysing both the transport process and the spatial conditions of the staircase.

The analysis demonstrated that even when specialised evacuation equipment is available, the effectiveness and safety of evacuation procedures are strongly dependent on the quality of spatial design. Narrow staircases, lack of landings, poorly designed handrails, or exposed technical installations can significantly hinder manoeuvring of the evacuation chair and increase risks for both the evacuated person and the operator.

Workshop experiences had a noticeable impact on students' approach to safety and accessibility. In subsequent design tasks, participants more frequently considered evacuation scenarios, the needs of users with reduced mobility, and the necessity of designing spaces that support effective emergency operations.

3.5. Educational value and relevance for the ERGOART project

The use of an evacuation chair in education provides a practical extension of theoretical knowledge by exposing students to real-world challenges associated with the evacuation of people with disabilities. Direct interaction with the device fosters empathy, responsibility, and a deeper understanding of the designer's role in ensuring user safety.

The outcomes of the workshops confirm that evacuation chairs constitute a valuable educational tool supporting the objectives of the ERGOART project. Integrating safety engineering, ergonomics, and universal design within experiential learning activities contributes to the development of competencies essential for creating safe, accessible, and inclusive built environments.

4. Using DIALux as a 3D modelling tool for designing inclusive workplaces

4.1. Background

Designing workplaces that accommodate people with disabilities requires careful planning of spatial layout, lighting, and accessibility features. While DIALux is best known as a professional lighting design software, its advanced 3D modelling and simulation capabilities make it an unexpectedly powerful tool for designing inclusive work environments. For educators introducing digital tools for ergonomic and accessible design, DIALux offers an approachable yet technically sophisticated platform to explore spatial design through realistic visualization.

At its core, DIALux enables users to construct full 3D environments, from individual workstations to complete office layouts. The software allows designers to import or create architectural models, define surfaces, and arrange furniture, fixtures, and pathways in three dimensions. These capabilities are particularly useful for visualizing how people with mobility impairments, such as wheelchair users, navigate through work areas. By accurately setting spatial dimensions and clearances, educators can guide students to test whether circulation routes, door widths, desk heights, and turning radii comply with accessibility standards like ISO 21542 guidelines.

One of DIALux's strengths lies in its precision and visual realism. The 3D rendering engine provides realistic views of how a workspace looks and functions from different perspectives that are helpful when evaluating design usability from a seated or standing position. Designers can simulate the line of sight for individuals with varying eye levels or restricted visual fields, offering a practical way to assess how well important visual cues (signs, control panels or pathways) are perceived within the space.

For users with visual impairments, lighting plays a key role in accessibility, and here DIALux's native lighting functions become especially relevant. The program allows users to model both natural and artificial lighting conditions, analyse luminance distribution, and evaluate glare risk. By simulating contrast ratios and brightness gradients, educators can demonstrate how lighting design directly influences visual comfort and safety. For instance, balanced illumination along circulation routes reduces shadows that might confuse someone with low vision, while task-specific lighting improves usability of shared work areas.

DIALux also supports interoperability with other design tools such as AutoCAD, Revit, or SketchUp, allowing accessible design concepts developed in one program to be refined and visualized in DIALux. This makes it valuable not only for lighting engineers but also for ergonomics and design educators who want to integrate accessibility awareness into 3D design training.

Because DIALux is freely available and supported by a wide community of users, it offers an accessible entry point into professional-grade 3D simulation without steep licensing barriers. Educators can use it to engage students in hands-on exploration of spatial inclusivity—testing designs, visualizing improvements, and understanding how design decisions affect workers with different needs.

4.2. Software outline

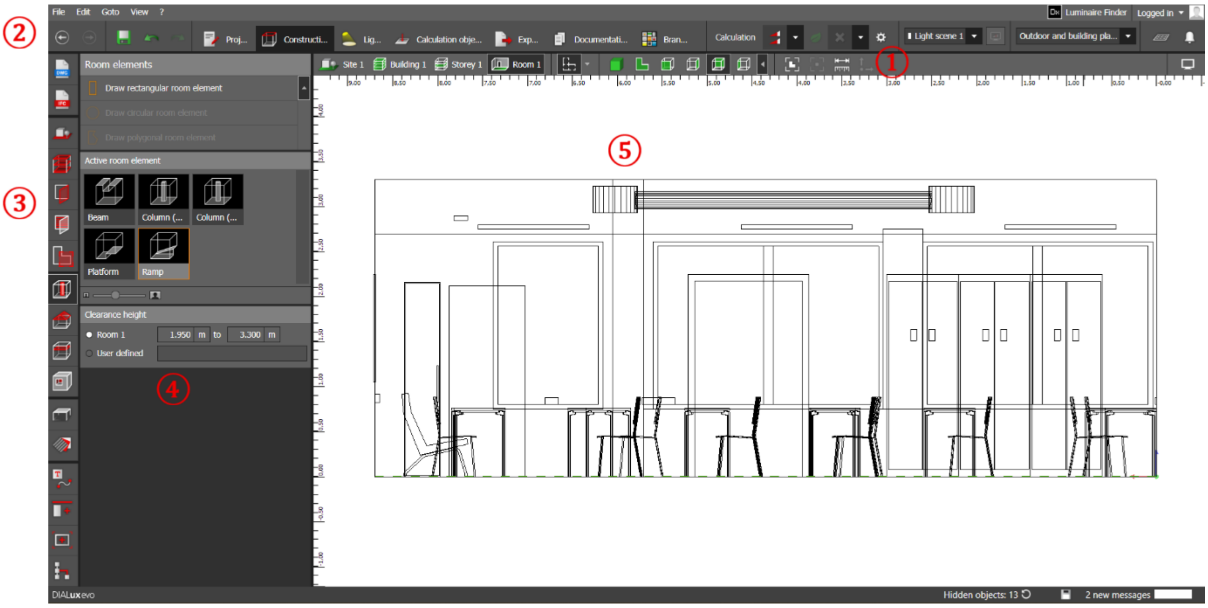
DIALux is a constantly evolving software platform, with updates released regularly to improve performance, expand functionality, and enhance user experience. At the time of writing, DIALux evo 13.2 has the following minimum hardware and system requirements: CPU with SSE2-support 4 GB RAM (min. 2 GB), OpenGL 3.2 graphics card (1 GB RAM), Windows 10 from version 1803 (Build 17134) / Windows 11 (64 bit), resolution min. 1920 × 1080 px.

Although Linux and macOS are not officially supported, DIALux can often be run successfully on these systems using virtual machine software or Windows emulation tools. This provides users of non-Windows operating systems a practical workaround, although performance and stability may vary depending on hardware configuration.

DIALux's user interface can be displayed in a wide range of languages, increasing accessibility for learners and professionals worldwide. Supported languages include: Czech, Danish, German, Estonian, English (UK/US), Spanish, French, Italian, Hungarian, Dutch, Norwegian, Polish, Portuguese, Romanian, Slovenian, Finnish, Swedish, Turkish, Ukrainian, Vietnamese, Greek, Russian, Korean, Simplified Chinese, Traditional Chinese, Japanese.

DIALux supports both indoor and outdoor lighting and spatial design, making it a versatile tool for various design applications. The user interface layout (as shown in Figure X) is organized to give users clear control over every aspect of a project:

- View Toolbar (1): This toolbar allows users to switch between different project levels (site, building, floor, or room) and to change the viewing direction between 2D (top or side) and 3D perspectives. These flexible viewing options are crucial for assessing design elements in spatial context.
- Main Horizontal Toolbar (2): Positioned at the top of the workspace, this toolbar provides access to core functions and determines the available tools displayed in the vertical toolbar.
- Vertical Toolbar (3): Located at the left side of the workspace, this toolbar changes dynamically based on the user's selection from the horizontal toolbar. It contains the primary modelling tools for creating and editing design elements such as doors, windows, furniture, or lighting objects.
- Properties Panel (4) displays detailed information and adjustable parameters for the currently selected item. For example, when the category "Room Elements" is selected in the vertical toolbar, the properties panel allows the user to activate specific room elements (e.g., a ramp) and define their dimensions or other attributes.
- Main Workspace (5): This is the central 2D/3D modelling area where design elements are placed, edited, and visualized. Active elements from the properties panel can be dragged directly into the workspace, allowing intuitive interaction and immediate visual feedback.



Clearance height: Room 1 1.950 m to 3.300 m

Figure. Five main panels of DIALux user interface: (1) - view toolbar, (2) - main horizontal toolbar, (3) - vertical toolbar, (4) – properties panel, (5) - main workspace.

The structure and interactive layout makes DIALux both powerful and user-friendly, suitable for professional designers as well as students learning the fundamentals of ergonomic and accessible workplace.

4.3. Case study results

Students from a wide range of academic and professional backgrounds can learn the basics of DIALux relatively quickly. The minimum time required to introduce the fundamental tools and interface of the software is around 45 minutes. However, experience shows that dedicating two 45-minute sessions produces significantly better results. The extended schedule allows students to progress at a comfortable pace and provides time for additional support for those who may be less familiar with digital modelling environments.

DIALux benefits from a large global user community and an abundance of free online tutorials, particularly on YouTube, which can be invaluable for students who wish to explore more advanced design functions independently. These resources make it easier for learners to troubleshoot issues, deepen their understanding, and experiment with more complex modelling and lighting scenarios beyond the classroom.

For the best learning outcomes, it is recommended that the teaching activity focus on modelling the actual classroom where students are learning to use DIALux. This approach provides a clear and relatable goal that students can immediately see the connection between the software and their physical environment. Working on a familiar space helps them understand spatial relationships, object dimensions, and accessibility considerations more intuitively. It also allows instructors to demonstrate step-by-step how to model real spaces, define materials, and adjust viewpoints in a controlled and easily verifiable setting.

An additional 45-minute session can be allocated for the introduction and explanation of the homework assignment, which ideally takes the form of a group project. Because DIALux is free to download and use, each student can install it on their personal computer, enabling collaborative learning outside the classroom. Project files are lightweight and can be easily shared, allowing groups to work on different design alternatives, analyse each version, and later combine the best ideas into a final, optimized design proposal. This process not only reinforces technical skills but also develops teamwork and critical analysist that are key competencies in ergonomic and inclusive workplace design.

A particularly valuable feature of DIALux is its ability to adjust the viewing perspective to any height or angle. This flexibility allows users to simulate the view from a wheelchair user's level, for example, or to explore how a space appears from different visual positions. Such functionality helps students understand accessibility challenges and the importance of sightlines and spatial flow in inclusive design. By experimenting with these features, learners can identify potential design issues early and propose evidence-based improvements that enhance usability for all.

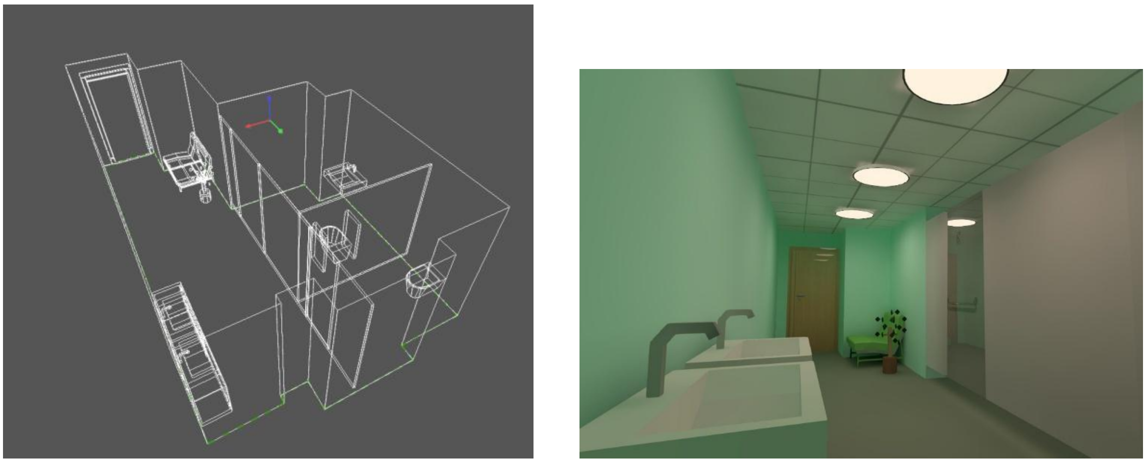


Figure. X-ray view of the bathroom on the left and wheelchair viewpoint on the right.

5. Using Ema Work Designer for ergonomic workstation design

5.1. Background

Ema Work Designer is a specialized software tool supporting the design of ergonomic workstations and the analysis of physical loads resulting from performed work activities. The software enables digital modelling of the work environment and simulation of interactions between the worker and the workstation, allowing ergonomic assessment already at the design stage or during the modernization of work processes.

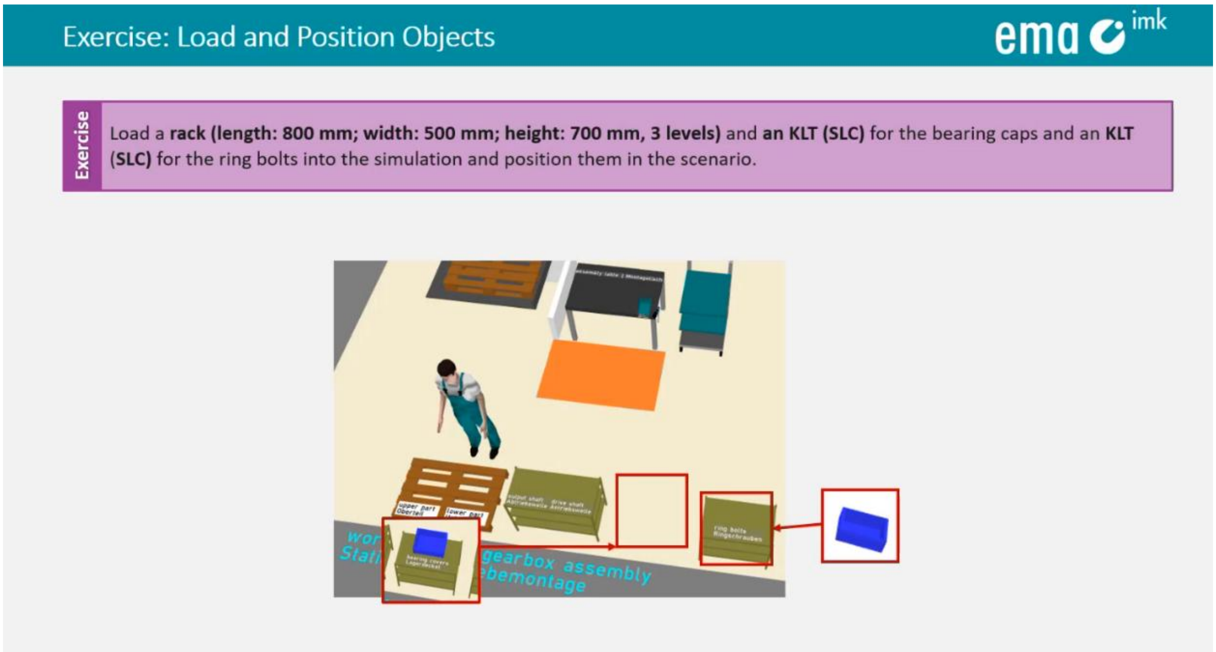
In the context of the ERGOART project, this tool was used as part of innovative training materials supporting education in ergonomics, workstation design, and the employment of people with disabilities. Ema Work Designer enables the analysis of the impact of work organization, body posture, and anthropometric parameters on work safety and comfort, which is particularly important in the context of long-term employment of workers with functional limitations.

5.2. Software outline

Ema Work Designer belongs to the class of digital human modelling (DHM) tools, enabling the simulation of human work in a virtual environment. The software allows the representation of workstations, tools, and surrounding elements, as well as the definition of sequences of work activities performed by a virtual worker.

The software enables the assignment of anthropometric models to simulated workers and the analysis of body postures and ranges of motion during task execution. Built-in ergonomic assessment methods, such as RULA, REBA, and OWAS, allow for quantitative evaluation of ergonomic risk and the identification of activities and postures generating excessive musculoskeletal load.

The analysis results are presented in the form of indicators and visualizations, enabling comparison of different workstation layout variants and supporting the decision-making process. The intuitive user interface makes the software suitable for use by both professionals and within the higher education teaching process.



Exercise: Load and Position Objects

ema imk

Exercise

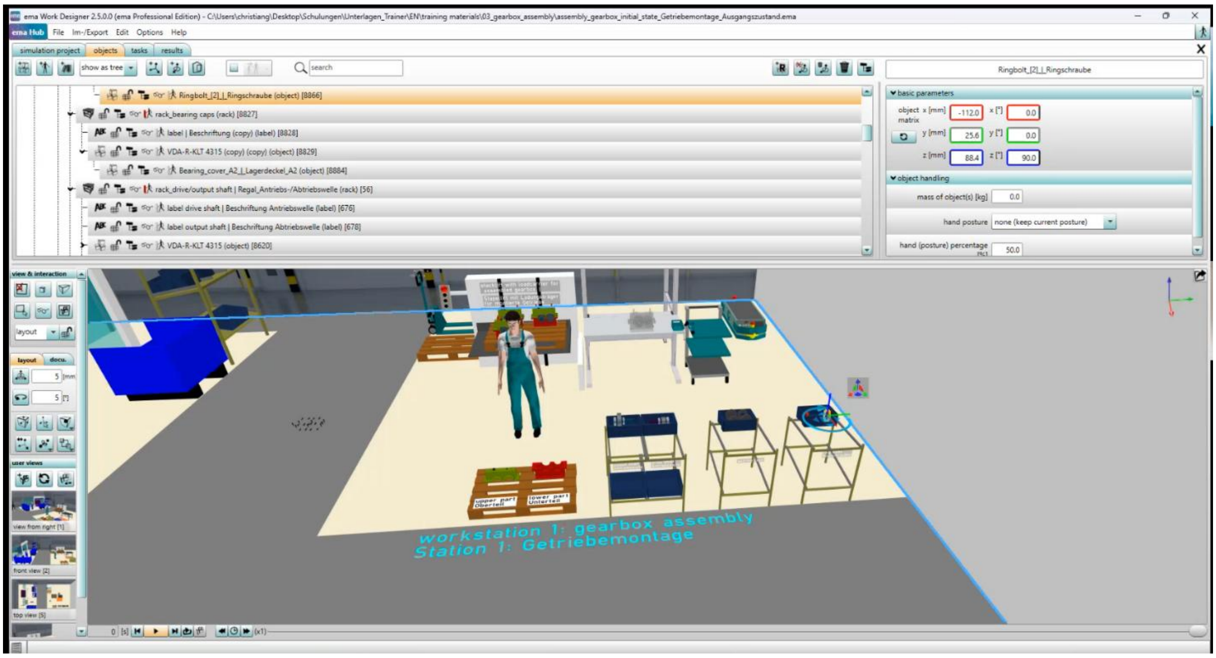
Load a **rack (length: 800 mm; width: 500 mm; height: 700 mm, 3 levels)** and **an KLT (SLC)** for the bearing caps and an **KLT (SLC)** for the ring bolts into the simulation and position them in the scenario.

Figure 5.1. Virtual workstation model with a digital human simulation in Ema Work Designer.

5.3. Case study results

The application of Ema Work Designer within the project activities enabled the implementation of a case study focused on the ergonomic analysis of a workstation and the assessment of the impact of selected design solutions on the worker's physical load. The case study involved the digital representation of an example workstation and the definition of a sequence of basic work activities.

Based on the conducted simulations, an ergonomic risk assessment was performed using the available analytical methods. The analysis of the results allowed the identification of body postures and work phases characterized by an increased level of physical load, as well as the indication of areas requiring design modifications.



ema Work Designer 2.5.0.0 (ema Professional Edition) - C:\Users\christiang\Desktop\Schulungen\Unterlagen_Trainer\EN\training materials\03_gearbox_assembly\assembly_gearbox_initial_state_Getriebemontage_Ausgangszustand.ema

- Ringbolt_[2]_|_Ringschraube (object) [8866]
- rack_bearing caps (rack) [8827]
  - label | Beschriftung (copy) (label) [8828]
  - VDA-R-KLT 4315 (copy) (copy) (object) [8829]
    - Bearing_cover_A2_|_Lagerdeckel_A2 (object) [8884]
- rack_drive/output shaft | Regal_Antriebs-/Abtriebswelle (rack) [56]
  - label drive shaft | Beschriftung Antriebswelle (label) [676]
  - label output shaft | Beschriftung Abtriebswelle (label) [678]
  - VDA-R-KLT 4315 (object) [8620]

Ringbolt_[2]_|_Ringschraube

basic parameters

object matrix			
x [mm]	-112.0	x [°]	0.0
y [mm]	25.6	y [°]	0.0
z [mm]	88.4	z [°]	90.0

object handling

mass of object(s) [kg] 0.0
hand posture none (keep current posture)
hand (posture) percentage [%] 50.0

Figure 5.2. Example of an educational ergonomic simulation of a gearbox assembly workstation in Ema Work Designer.

In the next stage, alternative workstation layout variants were developed, including changes in work surface height, tool arrangement, and movement ranges. A comparison of ergonomic assessment results for individual variants demonstrated the possibility of significantly reducing ergonomic risk through relatively minor structural and organizational modifications.

The case study also took into account anthropometric diversity and functional limitations of users. Simulations conducted for worker models with different physical parameters confirmed the validity of applying an inclusive design approach in workstation design and highlighted the importance of adapting the work environment to the capabilities of people with disabilities.

The obtained results confirm that Ema Work Designer is an effective tool supporting the achievement of the ERGOART project objectives in the area of developing innovative and interactive teaching methods. The software enables a practical combination of theoretical knowledge with the analysis of real ergonomic problems, supporting the development of competencies necessary for designing safe, accessible, and ergonomic workplaces.

6. Interactive teaching tools (LearningApps, Genially, Kahoot)

6.1. LearningApps

6.1.1. Crossword

Within the LearningApps online platform, **an interactive crossword puzzle** on the topic Disability in the Workplace has been created. The tool is designed as a learning activity that promotes awareness of rights, responsibilities, and good practices in the employment of people with disabilities in an engaging and straightforward way.

The crossword contains six key terms related to the most important concepts and measures that contribute to an inclusive working environment. Participants solve the puzzle by independently identifying and entering the correct terms, which encourages reflection and reinforces knowledge without any pre-given clues.

Link (Eng): https://learningapps.org/watch?v=pq1y30rij25

Link (Slo): https://learningapps.org/watch?v=psvkjh0ha25

6.1.2. Matching Pairs

This interactive activity focuses on **matching images with the correct terms** related to Work Aids and Assistive Technology. The activity is designed for participants to match images with the correct terms, encouraging visual recognition and reinforcing knowledge in this field.

The tool contains 11 images, each of which must be correctly paired with its corresponding concept. This approach promotes active participation, stimulates critical thinking, and strengthens understanding and long-term retention through the combination of visual and verbal information. The interactive nature of the tool increases participants' motivation and supports the transfer of acquired knowledge into practice.

Link (Eng): https://learningapps.org/watch?v=pkpx9s2c525

Link (Slo): https://learningapps.org/watch?v=pjcxx6wy525

6.1.3. Horse race

This interactive activity is designed as a quiz with a built-in competitive element to enhance engagement. The focus of the quiz is on ergonomic assessment methods. Learners are presented with five questions, each addressing the type of task or context where a specific method is most appropriately applied.

The quiz is presented in a horse race format, where each player is represented by a virtual horse on a racetrack. Horses advance as players answer questions correctly. The activity can be played solo (against the computer opponents) or in multiplayer mode, where participants compete against each other. This game-like format adds a motivational dynamic, encouraging active participation and reinforcing the learning objectives in a fun and interactive way.

Link (Eng): https://learningapps.org/watch?v=p12hr7j5a25

6.1.4. Matching Pairs on Images

This interactive activity is designed to explore the challenges that a person with a hearing impairment may experience when using a restroom. Learners are presented with a PIM diagram and are asked to assess the extent of the identified issues. Some answers are already marked on the diagram, and participants are required to add four additional answers independently. After completing the task, a pop-up window appears with explanations for the correct solutions.

The activity supports the development of awareness and problem-solving skills related to ensuring accessibility in various environments. The knowledge gained can be directly applied when designing or adapting real-life workplaces to better support employees with disabilities.

Link (Eng): https://learningapps.org/watch?v=pn2j78bt325

6.1.5. Sort into groups

This interactive task is designed to support structured thinking around the challenges that people with disabilities may face in the workplace. Learners are presented with a range of real-life examples illustrating various aspects impact employment.

The core task is to analyse each example and classify it according to the type of barrier it represents. The barrier categories include:

- Physical barriers (e.g. inaccessible buildings or workstations)
- Technological barriers (e.g. software that is incompatible with assistive devices)
- Communication barriers (e.g. lack of sign language interpretation)
- Organizational barriers (e.g. inflexible work schedules or lack of accommodation procedures)
- Legislative or policy barriers (e.g. outdated regulations or unclear policies)
- Attitudinal barriers (e.g. stereotypes or bias from coworkers or management)

The task encourages critical reflection on how these barriers can be identified and addressed in real-world employment contexts.

Link (Eng): https://learningapps.org/display?v=pvcoubzv525

6.1.7. Simple Order

This interactive activity focuses on understanding the phases of the design process in ergonomics and human-centered system development. Participants are presented with short descriptions of each phase and are asked to place them in the correct sequential order.

The activity encourages users to actively analyze and compare process steps, promoting a deeper understanding of how design progresses from identifying needs to evaluating the final system in use.

By engaging with the content in a structured and hands-on format, learners strengthen their ability to recall the process phases and understand how each stage connects logically to the next.

The visual layout and drag-and-drop interaction support active participation, making the learning experience more dynamic and memorable. This approach not only reinforces theoretical knowledge but also helps participants apply the design process more confidently in real-world scenarios.

Link (Eng): https://learningapps.org/display?v=p934jkd6325

6.2. Genially

6.2.1. Millionaire

Participants can engage in the interactive "Millionaire" game, which consists of 10 questions on the topic of Work Requirements Analysis and Ergonomic Risk Assessment. Each correct answer advances the participant up the scoring ladder, up to a maximum of 500,000 points.

For each question, 30 seconds are allowed, encouraging quick thinking and decision-making. The game provides an interactive and motivational way to test and reinforce professional knowledge, while also promoting concentration, strategic thinking, and tracking progress along the scoring ladder.

Link (Eng): https://view.genially.com/68bf0e89ff8b74cf1fb48ebe/interactive-content-quiz-milionario

Link (Slo): https://view.genially.com/68beb48b04f10859d6d5c755/interactive-content-milijonar

6.3. Kahoot

6.3.1. Quiz

This interactive Kahoot quiz consists of 10 questions presented as multiple-choice or true/false items, offering a varied approach to knowledge assessment. The questions focus on Ergonomic Principles and their Application in Design.

The quiz encourages active participant engagement, quick thinking, and decision-making, while providing an effective way to review and reinforce knowledge in an interactive and enjoyable format. This form of learning enhances understanding of ergonomic theory and its practical application in the design of work environments and tools.

Link (Eng): https://kahoot.it/challenge/05581862?challenge-id=3e07936d-1239-439b-9cd1-fb2ccc5dd71c_1758785891680

PIN: 05581862

Link (Slo): https://kahoot.it/challenge/09580251?challenge-id=3e07936d-1239-439b-9cd1-fb2ccc5dd71c_1758785848490

PIN: 09580251

6.4. ErgoART Interactive Teaching Tool - Work Aids and Assistive Technologies

6.4.1. Background

Within the ErgoART project, an interactive web-based educational tool entitled Interactive Teaching Tool – Work Aids and Assistive Technologies was developed to support the acquisition of practical competencies in the selection of assistive technologies (AT) for employees with disabilities.

While previous tools presented in this chapter (LearningApps, Genially, Kahoot) focus primarily on knowledge reinforcement and formative assessment, this tool introduces a scenario-based decision-making model, simulating real-life workplace problems. The aim is not to test memorized knowledge, but to develop analytical skills related to matching functional limitations with appropriate technological solutions.

The tool is available online as a standalone interactive module and may be used both in self-directed learning and in trainer-led sessions.

Link:

https://kamilwrobel8.github.io/ErgoART_Interactive_Teaching_Tool_Work_Aids_and_Assistive_Technologies/

6.4.2. Tool structure and functionality

The tool operates on the basis of a scenario–technology matching matrix. For each scenario variant, assistive technologies are classified as:

- CORE - key technologies directly addressing the main problem,
- SECONDARY - supportive but not essential solutions,
- INCORRECT - technologies not adequate for the scenario.

The user selects one of six workplace scenarios (e.g., mobility impairment, visual impairment, hearing impairment, cognitive difficulties). Each scenario contains three randomly generated variants.

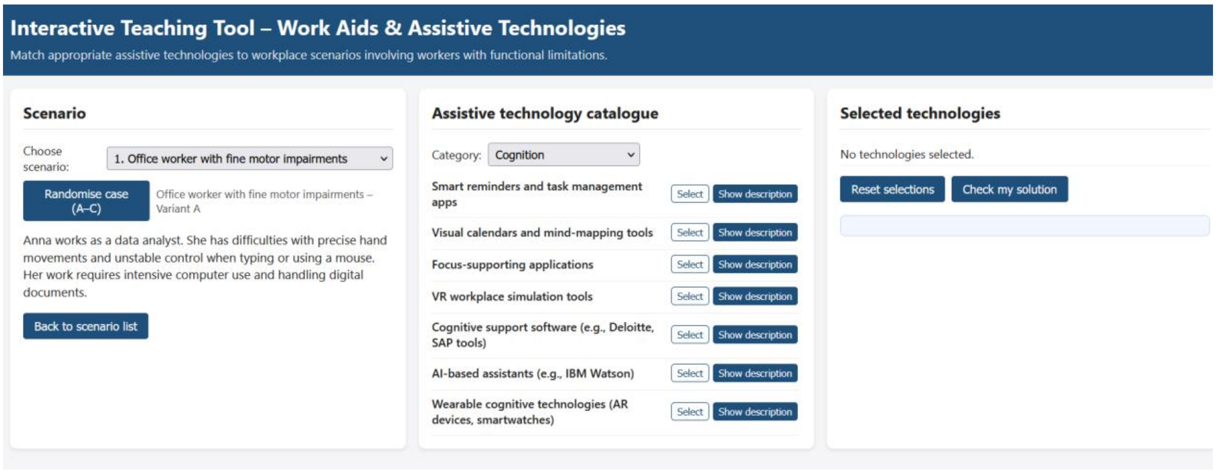
The main working screen includes:

- a scenario description panel,
- a categorized assistive technology catalogue (Mobility, Vision, Hearing, Communication & Input, Cognitive, Environment/IoT),
- a selection panel displaying chosen technologies.

After submitting the solution, the system automatically evaluates the selection and provides:

- qualitative feedback (Fully correct / Partially correct / Incorrect),
- numerical summary (CORE, SECONDARY, INCORRECT selections).

The structure enables repeated attempts and reflective learning.



Interactive Teaching Tool – Work Aids & Assistive Technologies

Match appropriate assistive technologies to workplace scenarios involving workers with functional limitations.

Scenario

Choose scenario: 1. Office worker with fine motor impairments

Office worker with fine motor impairments – Variant A

Anna works as a data analyst. She has difficulties with precise hand movements and unstable control when typing or using a mouse. Her work requires intensive computer use and handling digital documents.

Assistive technology catalogue

Category: Cognition

- Smart reminders and task management apps
- Visual calendars and mind-mapping tools
- Focus-supporting applications
- VR workplace simulation tools
- Cognitive support software (e.g., Deloitte, SAP tools)
- AI-based assistants (e.g., IBM Watson)
- Wearable cognitive technologies (AR devices, smartwatches)

Selected technologies

No technologies selected.

Figure 6.1. Main interface of the Interactive Teaching Tool – Work Aids & Assistive Technologies (scenario selection, assistive technology catalogue, and evaluation panel)

6.4.3. Educational application

The tool can be used:

- as a standalone e-learning activity,
- during workshops (individual or group work),
- as a practical complement to theoretical modules on assistive technologies and inclusive workplace design.

In educational practice, it supports:

- development of analytical and decision-making skills,
- understanding of functional limitations in work environments,
- differentiation between essential and supportive technological interventions.

6.4.4. Educational value and relevance for the ERGOART project

The Interactive Teaching Tool complements other digital and experiential tools used in the ERGOART project by focusing on practical workplace adaptation strategies.

Its flexible architecture allows easy modification of scenarios and technology classifications, ensuring scalability and long-term applicability in higher education and professional training contexts.