

EXCELLENCE IN HUMAN-CENTERED LOGISTICS 4.0

Grant Agreement Number: 101159664



D4.1 – POSTGRADUATE COURSE

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Deliverable Submission Date	31.07.2026
Dissemination Level	PU
Lead Beneficiary	NTNU

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1. Introduction

X-HuLog4.0 addresses the scope of the WIDERA 2023-ACCESS 02-01: TWINNING under the priority “spreading excellence and widening participation.” The project establishes cooperation with internationally leading research institutions – NTNU, TUDa, and USAAR – and allows defining strategies for building capabilities and establishing networks that help Vilnius Gediminas Technical University (VILNIUS TECH) to advance their R&I capabilities in human-centered logistics systems of the future (X-HuLog4.0).

The project entitled X-HuLog4.0 – Excellence in human-centered logistics 4.0 aims to fully realize and further develop the existing scientific potential of the widening partners VILNIUS TECH, which aims at scientific excellence in human-centered logistics systems of the future. While the focus is on widening partners, the project also enables the other partners to deepen their knowledge in this field and contribute to the advancement and adoption of X-HuLog4.0 results across Europe.

To this purpose, through its Work Packages (WP), X-HuLog4.0 intends to:

- increase the research and educational capabilities in Human-centered Logistics at VILNIUS TECH at the supporting partners;
- establish a long-term knowledge transfer between the contributing parties with a special focus on young-stage researchers;
- encourage the connection among researchers of the partner universities and other leading research institutes and promote networking;
- enable VILNIUS TECH to act as a knowledge center providing modern methodologies, logistic tools, and solutions in the area of human-centered logistics to transfer knowledge to the widening and associated countries;
- increase the industry and society's awareness on human-centered logistics and the value of a close collaboration with academia;
- foster scientific developments through increases in the number of publications, patents, participation in research programs, and new products or services development.

In particular, the WP4 objective is to improve excellence capacity and the research profile of VILNIUSTECH by transferring the knowledge of the use of automation/robotization for human-centered logistics to the staff at VILNIUSTECH about: the classification of automated/robotized solutions in logistics; the development of integrated models for the design of logistics system where automation/robotization are applied; the effects of the use of solutions for performance of logistics and human well-being (Human-Robot collaboration).

The following document represents Deliverable D4.1 and presents the postgraduate course developed by the project partners to improve knowledge related to the application of automation and robotization in human-centered logistics systems.

This document is not binding, and it contains guidelines and best practices coming from the experience of the partners. This first version was developed based on the online platform and the outcomes of WP2, WP3, and WP4 activities within the X-HuLog4.0 project.

The structure of this document is as follows:

- Chapter 1 presents the introduction to the document.
- Chapter 2 describes the objectives of the document.
- Chapter 3 describes the materials available on the online platform.
- Chapter 4 describes the guidelines for effective use and knowledge transfer of course materials.

2. Objectives of the Document

This document provides a structured narrative report summarizing the content delivered for the postgraduate course. The course materials were provided by three partner institutions for implementation at VILNIUS TECH. The course consists of three thematic modules: Industrial Applications, provided by NTNU; Decision Support and Optimization Models for Human-Centered Logistics, provided by the Technical University of Darmstadt; and Sustainable Intralogistics through Human–Robot Collaboration and Operator 4.0 Technologies, provided by Saarland University.

The objective of this document is to present the available course materials, describe their organization on the online platform, and provide guidance for their effective use in knowledge transfer activities within the X-HuLog4.0 project.

This document applies to all participants involved in the X-HuLog4.0 project.

3. Materials Available on the Online Platform

3.1 Overview of the Online Learning Platform

The online learning platform serves as the central repository for all course-related materials developed within the X-HuLog4.0 project. The platform has been designed to support efficient knowledge transfer and to provide students, instructors, and project partners with easy access to educational resources contributed by the partner universities.

3.2 Structure of the Course Materials

The available materials are organized according to the thematic modules of the postgraduate course. Each module contains lecture presentations, reading materials, interactive learning activities, quizzes, self-assessment exercises, references, and supplementary educational resources. The structure of the platform enables users to navigate through the content in a systematic manner while supporting both self-paced learning and instructor-led teaching activities.

3.3 Industrial Applications (NTNU Module)

The module Industrial Applications, provided by NTNU, focuses on human-centered approaches in logistics and industrial systems. The course materials are divided into four thematic modules covering human-centered system design, material handling and warehousing, human factors and ergonomics, and human-centered robotics in warehousing. Each module includes theoretical lecture materials, reading resources, interactive activities, quizzes, and self-evaluation tests designed to enhance learner engagement and practical understanding of Logistics 4.0 applications.

3.4 Decision Support and Optimization Models (TUDa Module)

The module Decision Support and Optimization Models for Human-Centered Logistics, provided by the Technical University of Darmstadt, introduces theoretical and practical approaches related to human factors, warehouse operations, decision support, and optimization models in logistics systems. The course consists of lecture materials and interactive quizzes addressing topics such as ergonomics in logistics, warehouse layout planning, pallet positioning strategies, warehouse management, and order-picking

optimization. The materials aim to strengthen competencies in human-centered logistics planning and operational decision-making within Logistics 4.0 environments.

3.5 Sustainable Intralogistics and Operator 4.0 (Saarland University Module)

The module Sustainable Intralogistics through Human–Robot Collaboration and Operator 4.0 Technologies, provided by Saarland University, introduces learners to sustainable intralogistics concepts and enabling Industry 4.0 and Industry 5.0 technologies. Developed by the Chair of Digital Transformation in Operations Management, the course includes self-learning lecture materials, quizzes, reflective exercises, references, videos, and additional reading resources. The lectures address topics such as sustainable intralogistics challenges, Operator 4.0 technologies, human–robot collaboration systems, wearable and sensor technologies, ethical aspects of human–robot interaction, and sociotechnical system design. The course concludes with a case-based mini-lecture that integrates the concepts presented throughout the course and encourages reflective learning.

3.6 Platform Resources and Features

In addition to the learning materials, the platform also provides supporting resources such as downloadable files, discussion forums, external learning links, videos, references, and assessment activities. The platform interface has been designed to facilitate accessibility, content sharing, learner interaction, and efficient dissemination of knowledge among project partners and course participants.

The following figures provide examples of the uploaded materials from all three course modules. Each figure indicates the corresponding module to demonstrate that the learning materials for NTNU, TUDa, and Saarland University are available on the online platform.

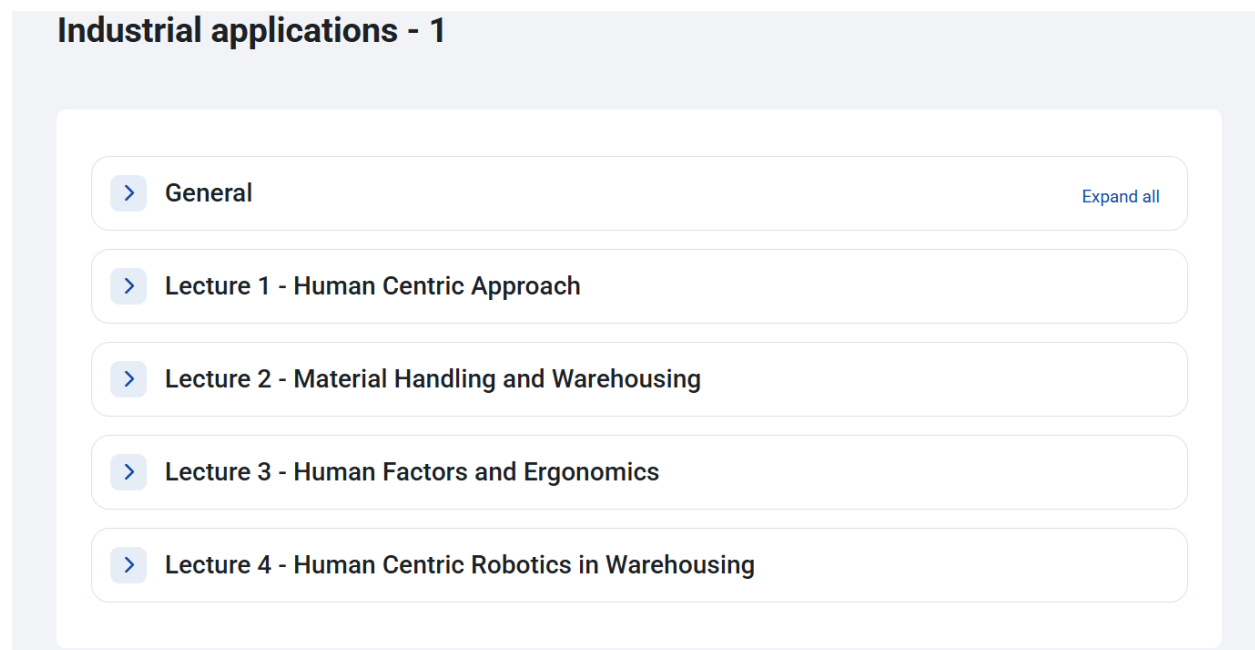


Figure 1. Example from the Online Platform — Industrial Applications module, NTNU

Decision support & optimization models for human-centered logistics

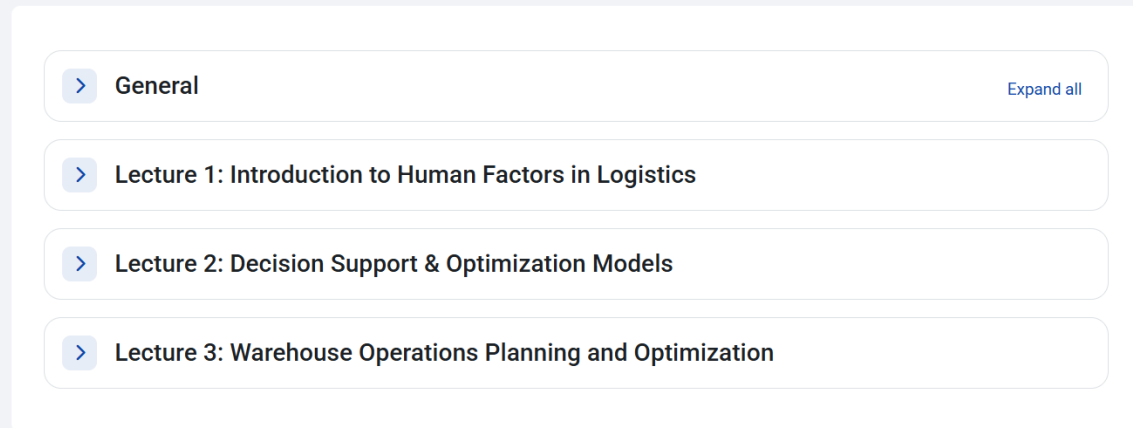


Figure 2. Example from the Online Platform — Decision Support and Optimization Models module, TUDa

Sustainable Intralogistics through Human–Robot Collaboration and Operator 4.0 Technologies

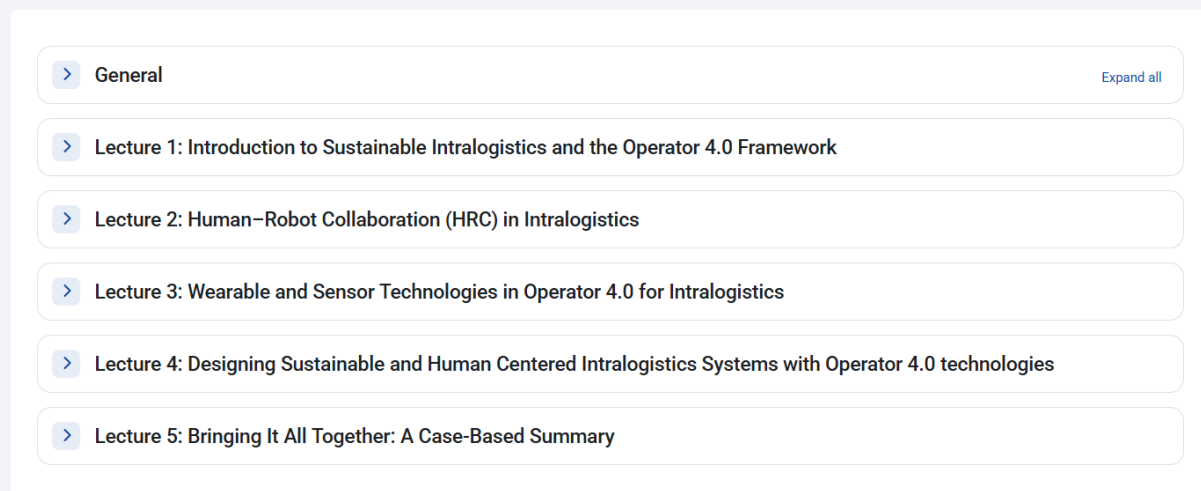


Figure 3. Example from the Online Platform — Sustainable Intralogistics and Operator 4.0 module, Saarland University

Figures 1-3 confirm that representative materials from all three postgraduate course modules have been uploaded and are available on the online learning platform.

4. Guidelines for Effective Use and Knowledge Transfer of Course Materials

This chapter provides guidelines for the effective use of the online learning platform and course materials to support knowledge transfer within the X-HuLog4.0 project.

4.1 Access to the Online Learning Platform

The online learning platform has been designed to support efficient and user-friendly access to the educational materials developed within the X-HuLog4.0 project. The platform enables students, instructors, and project partners to access course materials, complete learning activities, and participate in self-assessment exercises in a structured and flexible manner.

4.2 Course Structure and Navigation

Users can access the available courses through the main course page, where the three thematic modules developed by the partner institutions are presented.

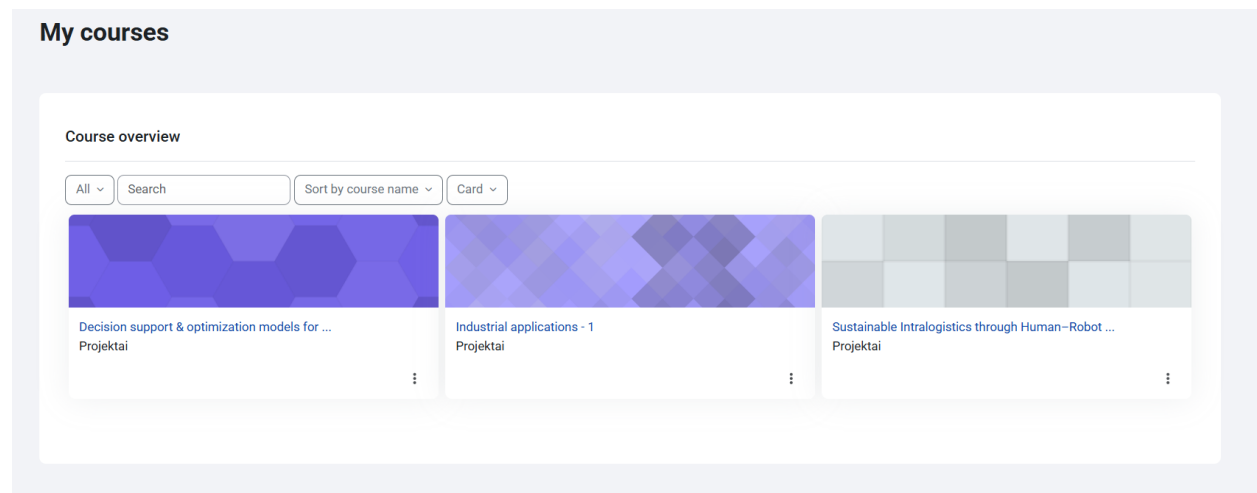


Figure 4. Courses on Online Platform

Each course module is organized into lectures and learning activities. The lecture structure enables users to follow the content sequentially and supports progressive knowledge development throughout the course.

▼	Lecture 1 - Human Centric Approach
	Theory - Human-Centric System Design
	Reading materials
	Interactive Activity - Round Robin
	Human-Centric Approach
▼	Lecture 2 - Material Handling and Warehousing
	Theory - Warehousing and Material Handling
	Reading materials
	Interactive Activity - MHE game
	Material Handling and Warehousing
▼	Lecture 3 - Human Factors and Ergonomics
	Theory - Ergonomics in Production and Logistics
	Reading materials
	Kahoot!
	Human Factors and Ergonomics
▼	Lecture 4 - Human Centric Robotics in Warehousing
	Theory - Human-centric robotized warehousing
	Reading materials
	Kahoot! - Robotized Warehousing

Figure 5. Example of Course Contents — Industrial Applications module, NTNU

▼

Lecture 1: Introduction to Human Factors in Logistics

 PDF

Introduction: Human factors aspects in logistics

In this set of slides, an introductory discussion has been carried out on human factors aspects in logistics area. Here, initially a basic understanding has been provided on how and why ergonomics is important in logistics. Then, some established ergonomic assessment methods are presented with illustrative examples.

 H-P

Quiz Lecture 1

 H-P

Quiz Lecture 1

▼

Lecture 2: Decision Support & Optimization Models

 PDF

Decision support model

In this module, a list of decision support models are presented. The models are developed based on warehouse layout options and various pallet positioning during order picking. All the models are analyzed keeping in mind human centred logistics design.

 H-P

Quiz Lecture 2

 H-P

Quiz Lecture 2

▼

Lecture 3: Warehouse Operations Planning and Optimization

 PDF

Warehouse management

This module provides a comprehensive look into modern warehouse management, focusing heavily on order picking, historically the most labor-intensive, costly, and critical phase of warehouse operations. The content bridges the gap between mathematical optimization and human-centric operational design, demonstrating how layout, technology, and workforce well-being must be meticulously synchronized to build a resilient supply chain.

 H-P

Quiz Lecture 3

 H-P

Quiz Lecture 3

Figure 6. Example of Course Contents— Decision Support and Optimization Models module, TUDa

▼ Lecture 1: Introduction to Sustainable Intralogistics and the Operator 4.0 Framework

At the end of this lecture, you will be able to:

1. Define intralogistics and discuss its present challenges.
2. Describe the industrial evolution until Industry 5.0.
3. Analyze how different Operator 4.0 technologies contribute to sustainability outcomes.
4. Compare their sustainability implications in intralogistics operations.

 [Lecture 1 -Slides](#)

 [Intralogistics : Sneak peek to an Amazon Fulfillment Center](#)

 [Challenges in intralogistics](#)

 [Lecture 1 - Further reading](#)

 [Quiz Lecture 1 - Check your knowledge](#)

▼ Lecture 2: Human–Robot Collaboration (HRC) in Intralogistics

At the end of this lecture, you will be able to:

1. Explain the needs and robot types used in intralogistics.
2. Explain fundamental human-robot interaction levels.
3. Analyse economic, environmental, and social sustainability dimensions in HRC.
4. Evaluate and design ethical HRC for improved sustainability and operator well-being.

 [Lecture 2 - Slides](#)

 [History of industrial robots](#)

 [Advanced robotic warehouse with AI](#)

 [Short Video - Ethical issues in human-robot interaction](#)

 [Lecture 2 - Further reading](#)

 [Quiz Lecture 2 - Check your knowledge](#)

▼ Lecture 3: Wearable and Sensor Technologies in Operator 4.0 for Intralogistics

At the end of this lecture, you will be able to:

1. Describe wearable devices, sensor types and their functions in intralogistics.
2. Evaluate challenges and ethical risks of physiological monitoring using wearable sensors.
3. Design an effective and ethical wearable sensor data-based decision framework for intralogistics.

 [Lecture 3 - Slides](#)

 [TechTalk: Wearable Devices For EHS Use Cases](#)

 [Right Sensors Used Right approach by NIOSH](#)

 [Lecture 3 - References and further reading](#)

 [Quiz Lecture 3 - Check your knowledge](#)

▼ Lecture 4: Designing Sustainable and Human Centered Intralogistics Systems with Operator 4.0 technologies

At the end of this lecture, you will be able to:

1. Define the key principles of sociotechnical systems (STS) theory.
2. Describe the main opportunities and challenges of human-robot systems in intralogistics.
3. Apply the STS framework to evaluate or design intralogistics systems.
4. Analyze interactions between the social and technical elements of robots and other Operator 4.0 technologies.
5. Critically evaluate the role of an STS perspective in supporting sustainable intralogistics with Operator 4.0 technologies.

 [Lecture 4 - Slides](#)

 [Short video on socio technical systems](#)

 [Lecture 4 - References and further reading](#)

 [Quiz Lecture 4 - Check your knowledge](#)

▼ Lecture 5: Bringing It All Together: A Case-Based Summary

In the previous lectures, we explored key concepts such as Operator 4.0, sustainable intralogistics, human–robot collaboration, wearable technologies are evolving.

In this last mini-lecture, we bring these concepts together through a single case: an e-commerce warehouse. The goal is to move from understanding informed decisions as the manager of this warehouse, considering sustainability and ethical implications.

Please answer the reflection questions on the final slide. They are not graded and are intended to support your learning.

 [Lecture 5](#)

Figure 7. Example of Course Contents - Sustainable Intralogistics and Operator 4.0 module, Saarland University

4.3 Learning Materials and Resources

The platform provides access to different types of learning materials, including lecture slides, reading materials, videos, external learning resources, and downloadable files. These resources are intended to support both theoretical understanding and practical learning.



Figure 8. Example of Lecture Material

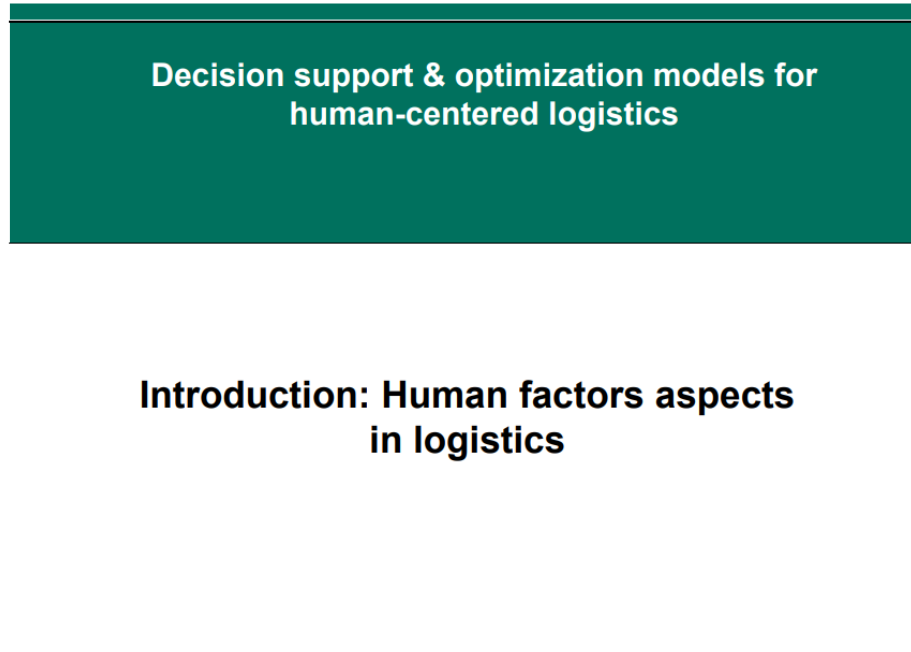


Figure 9. Example of Lecture Material

The slide features a light blue background with a subtle, abstract pattern of overlapping circles. The text is primarily in blue and black. At the top left, it identifies the project as 'Excellence in human-centered logistics 4.0' (X-HuLog4.0), spanning 2024-2027, project number 101159664, funded by EU Horizon-CSA. The main title is 'Lecture 1: Introduction to Sustainable Intralogistics and the Operator 4.0 Framework'. Below this, it mentions the 'Chair of Digital Transformation in Operations Management' at 'Saarland University'. The right side of the slide is a vertical stack of logos: Vilnius Tech (Faculty of Business Management), NTNU (Norwegian University of Science and Technology), Technische Universität Darmstadt, and Universität des Saarlandes. At the bottom right, there are logos for X-HuLog4.0 and the European Union, with the text 'Funded by the European Union'.

Excellence in human-centered logistics 4.0
X-HuLog4.0
2024-2027, Project No 101159664,
funded by EU Horizon-CSA

Lecture 1: Introduction to Sustainable
Intralogistics and the Operator 4.0
Framework

Chair of Digital Transformation in Operations Management
Saarland University

VILNIUS
TECH
Faculty of Business
Management

NTNU
Norwegian University of
Science and Technology

TECHNISCHE
UNIVERSITÄT
DARMSTADT

UNIVERSITÄT
DES
SAARLANDES

X-HuLog4.0

Funded by
the European Union

Figure 10. Example of Lecture Material

4.4 Interactive Learning Activities and Self-Assessment

Interactive learning activities and quizzes are integrated into the platform to support learner engagement and self-evaluation. Users are encouraged to complete the quizzes after each lecture to assess their understanding of the presented topics.

Excellence in human-centered logistics 4.0
X-HuLog4.0
2024-2027, Project No 101159664,
funded by EU Horizon-CSA

VILNIUS
TECH
Faculty of Business
Management

NTNU
Norwegian University of
Science and Technology

TECHNISCHE
UNIVERSITÄT
DARMSTADT

UNIVERSITÄT
DES
SAARLANDES

X-HuLog4.0

Funded by
the European Union

HAVE A FUN PROBLEM SOLVING!!!
LET'S DO A ROUND ROBIN

Fabio Sgarbossa
Professor of Industrial Logistics
Production Management Research Group & Logistics 4.0 Lab
Department of Mechanical and Industrial Engineering
Norwegian University of Science and Technology

Figure 11. Example of Interactive Tools

Kahoot!
GO

Discover Learn Present Make Join

Search public content

Sign up FREE

AmirZare

Kahoot
Ergonomics & Human Factors
Test your knowledge of ergonomics, human factors and ergonomics (HF&E), assessment methods, wearable tech, collaborative robotics, workload metrics, and key concepts from NIOSH, OWAS, PMES, and more. ...
[Show more](#)
► 25 plays 11 participants

Questions (14) Show answers

How familiar are you with ergonomics?

What does 'ergon' originally mean?

Kahoot session
Host live
Assign

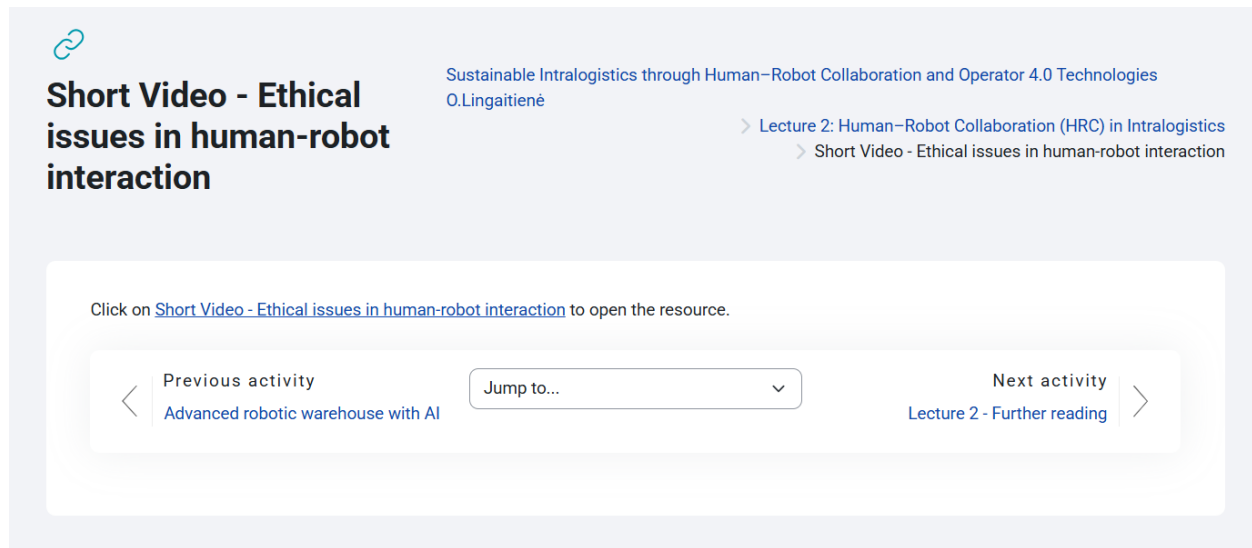
Kahoot self-study
Learn
Flashcards
Play solo

Updated 2 months ago • Visibility: Unlisted

Figure 12. Example of Interactive Tools

4.5 External Resources and Reflective Learning

Some modules additionally provide external learning resources, videos, and reflective exercises that encourage students to connect theoretical concepts with practical logistics and industrial applications.



 **Short Video - Ethical issues in human-robot interaction**

Sustainable Intralogistics through Human–Robot Collaboration and Operator 4.0 Technologies
O.Lingaitienė

- > Lecture 2: Human–Robot Collaboration (HRC) in Intralogistics
 - > Short Video - Ethical issues in human-robot interaction

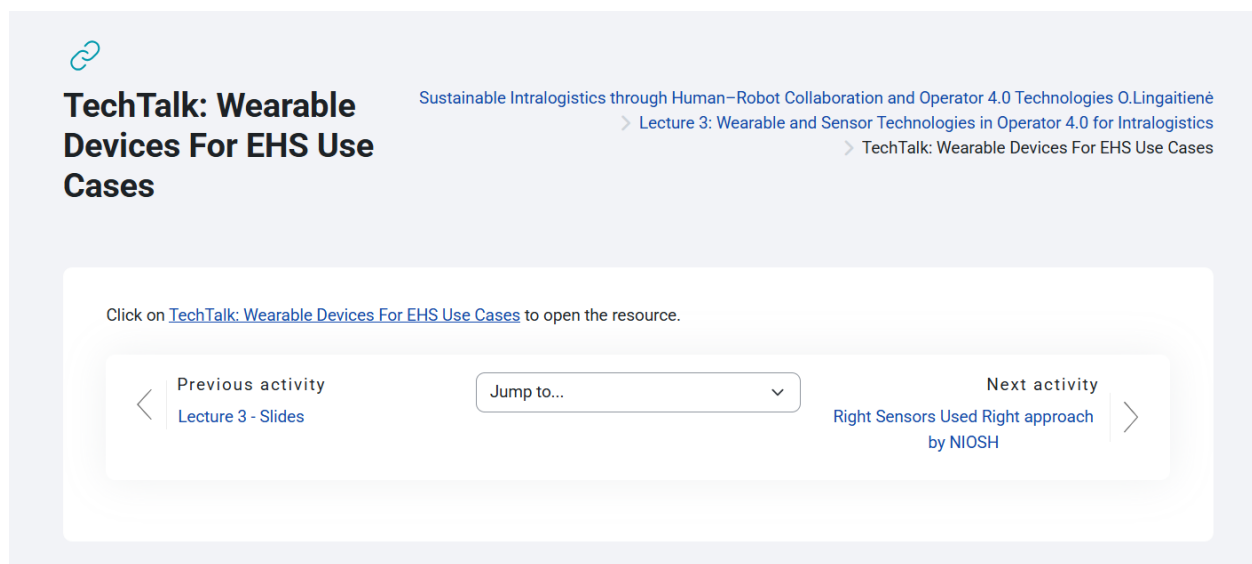
Click on [Short Video - Ethical issues in human-robot interaction](#) to open the resource.

< Previous activity
Advanced robotic warehouse with AI

Jump to... ▼

 Next activity
Lecture 2 - Further reading >

Figure 13. Example of External Resources



 **TechTalk: Wearable Devices For EHS Use Cases**

Sustainable Intralogistics through Human–Robot Collaboration and Operator 4.0 Technologies O.Lingaitienė

- > Lecture 3: Wearable and Sensor Technologies in Operator 4.0 for Intralogistics
 - > TechTalk: Wearable Devices For EHS Use Cases

Click on [TechTalk: Wearable Devices For EHS Use Cases](#) to open the resource.

< Previous activity
Lecture 3 - Slides

Jump to... ▼

 Next activity
Right Sensors Used Right approach by NIOSH >

Figure 14. Example of External Resources

4.6 Knowledge Transfer Recommendations

For successful knowledge transfer, students are recommended to follow the lecture sequence provided within each module, review the accompanying reading materials, complete the quizzes and self-assessment activities, and reflect on the practical applications of the presented concepts. Instructors may additionally integrate the materials into existing postgraduate courses or use selected modules as supplementary educational resources.

The modular and digital structure of the platform supports flexible learning, facilitates collaboration among partner institutions, and contributes to the long-term sustainability and reusability of the educational materials developed within the X-HuLog4.0 project.



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