EXCELLENCE IN HUMAN-CENTERED LOGISTICS 4.0

Grant Agreement Number: 101159664

D4.1 – POSTGRADUATE COURSE

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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 for 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.

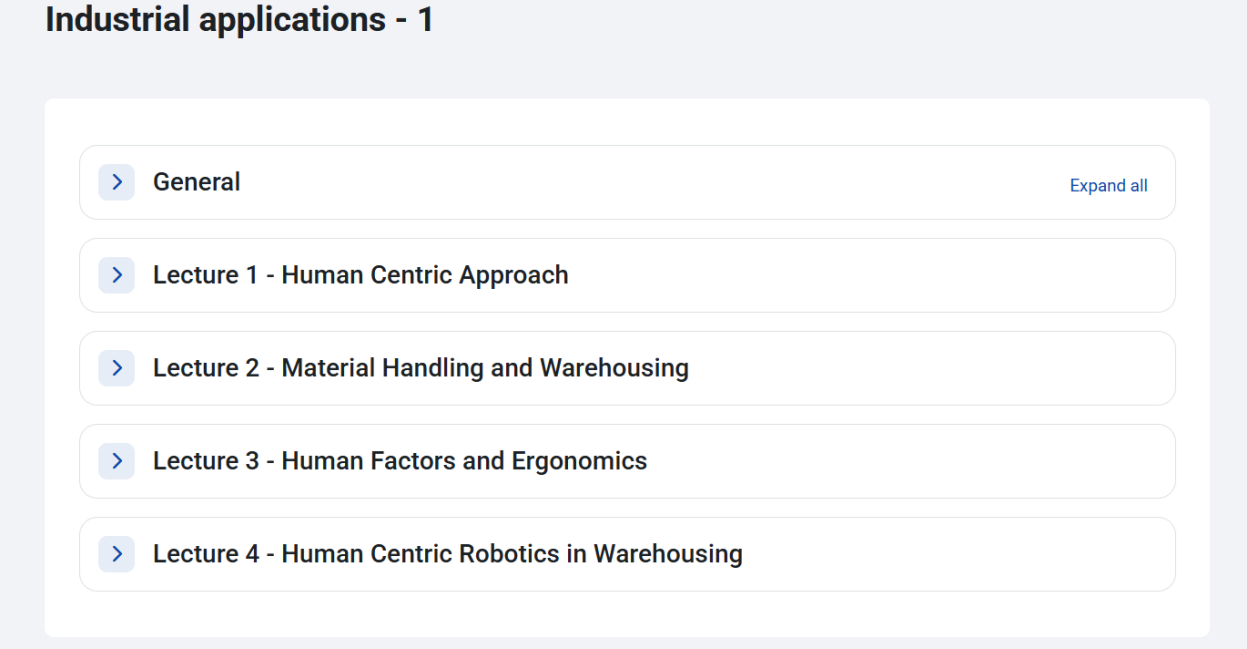

Figure 1. Example from the Online Platform — Industrial Applications module, NTNU

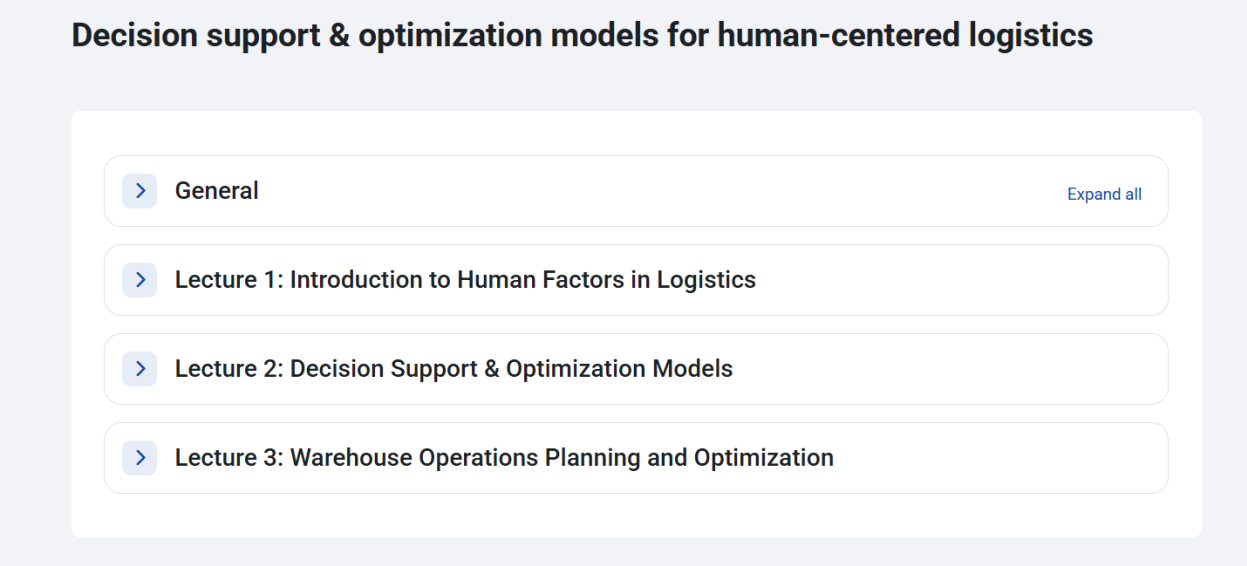

Figure 2. Example from the Online Platform — Decision Support and Optimization Models module, TUDa

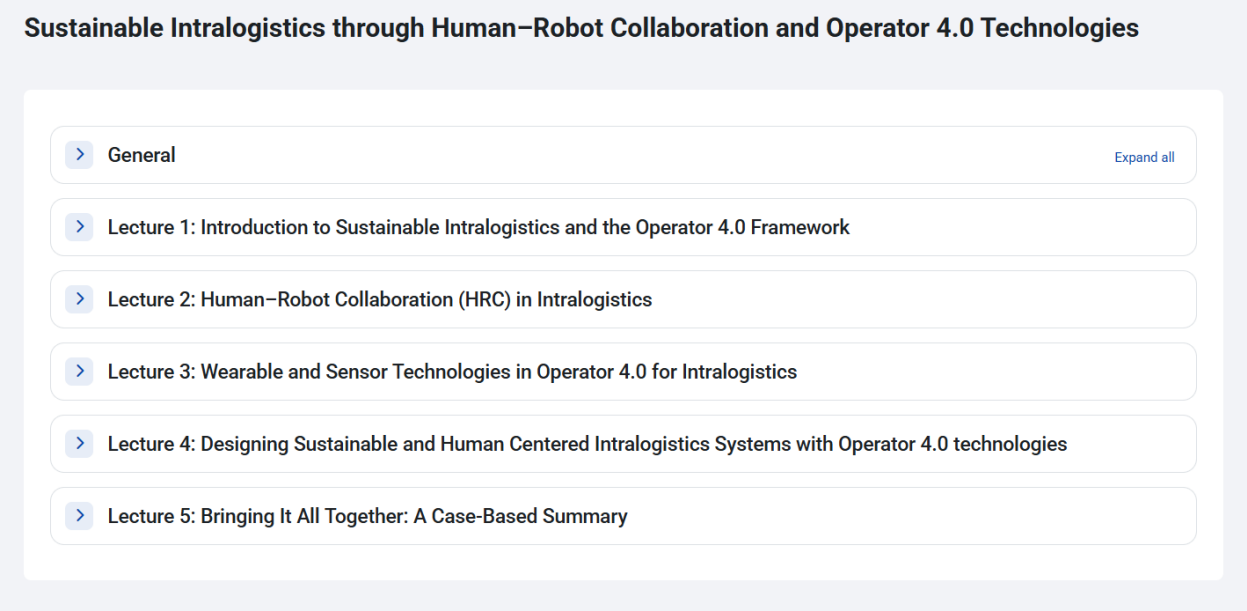

Figure 3. Example from the Online Platform — Sustainable Intralogistics and Operator 4.0 module, Saarland University

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.

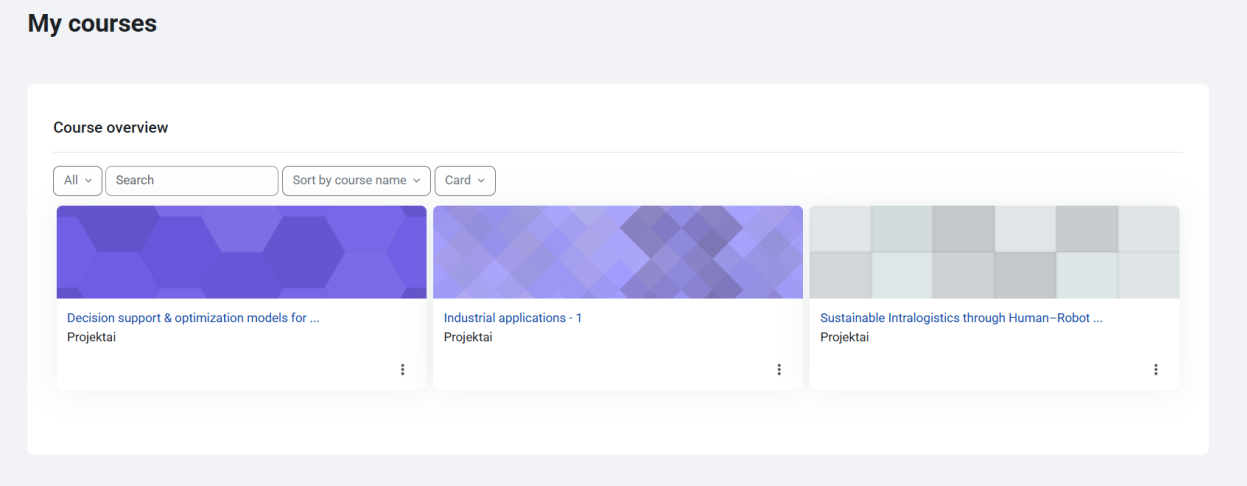

Figure 4. Courses on Online Platform

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.

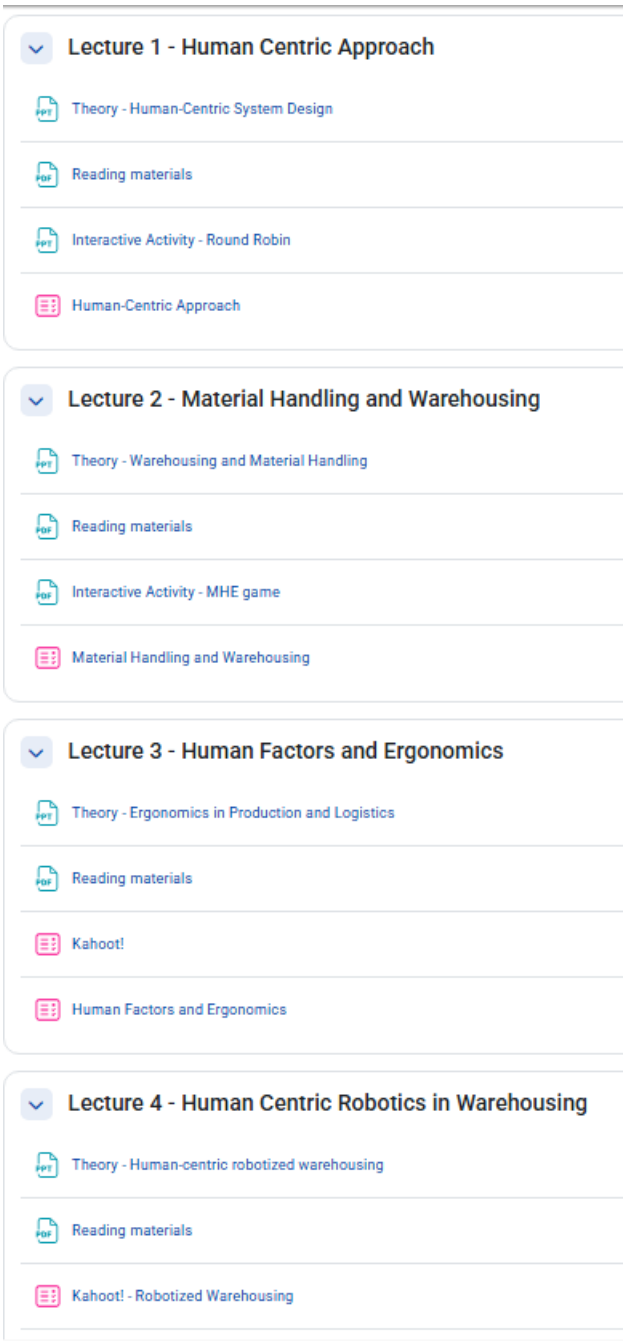

Figure 5. Example of Course Contents — Industrial Applications module, NTNU

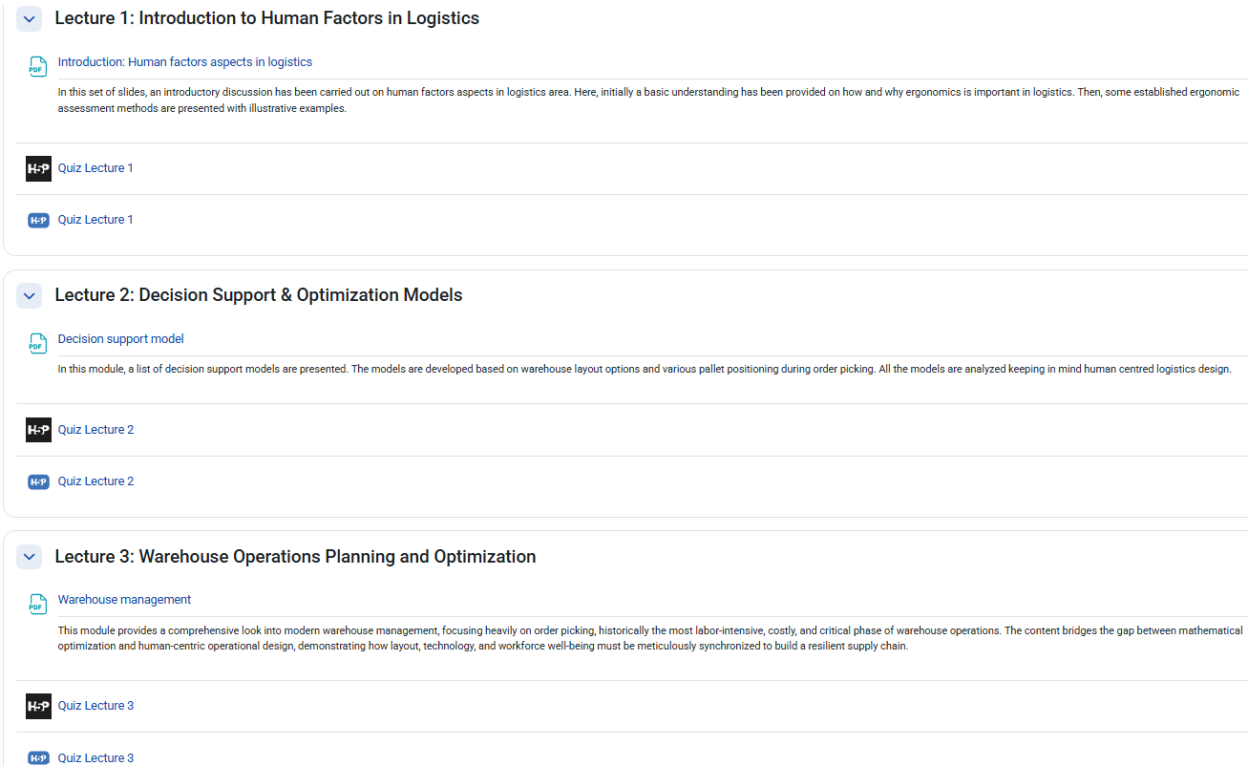

Figure 6. Example of Course Contents— Decision Support and Optimization Models module, TUDa

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

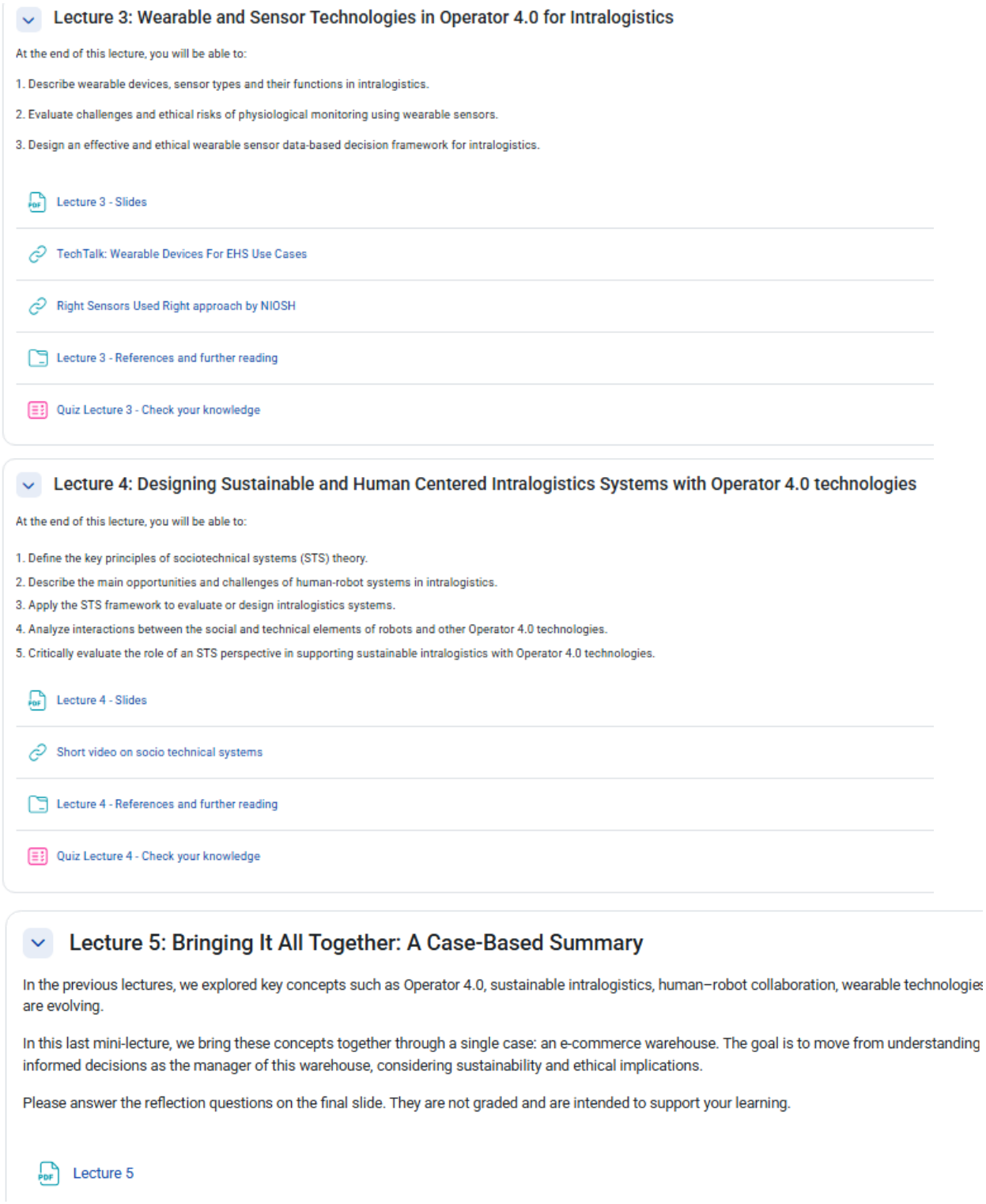

Figure 7. Example of Course Contents - Sustainable Intralogistics and Operator 4.0 module, Saarland University

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

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.

Figure 11. Example of Interactive Tools

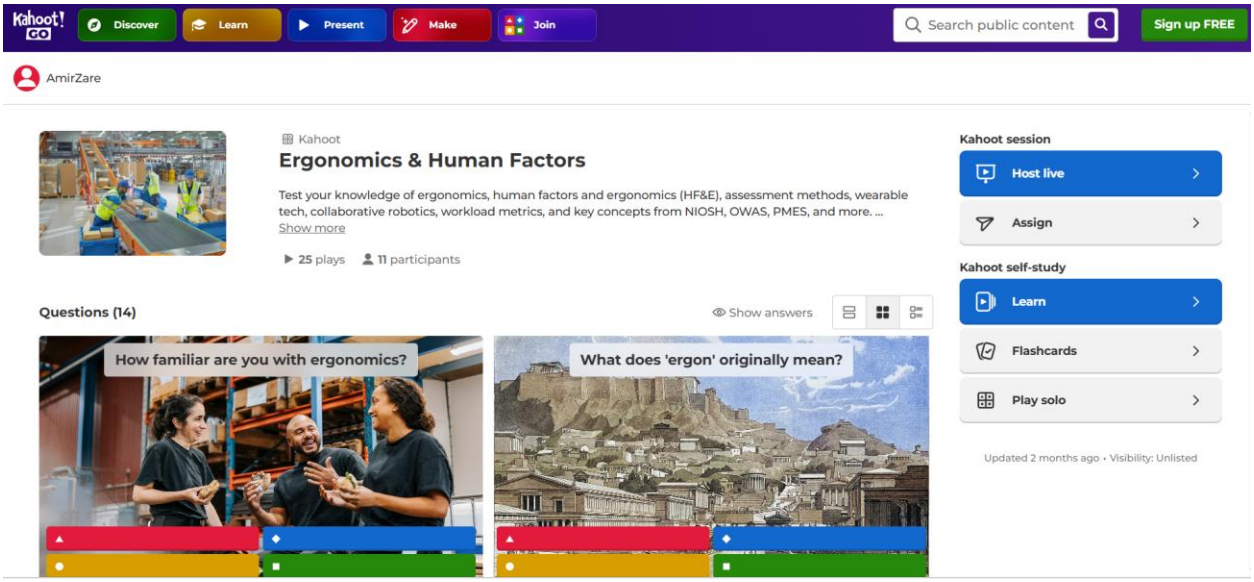

Figure 12. Example of Interactive Tools

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.

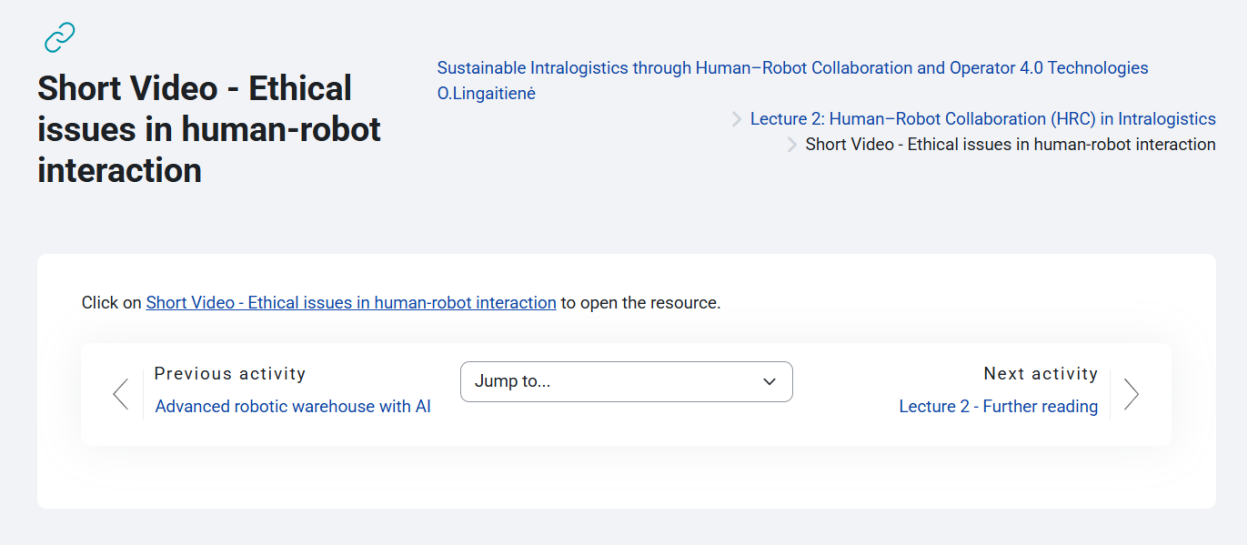

Figure 13. Example of External Resources

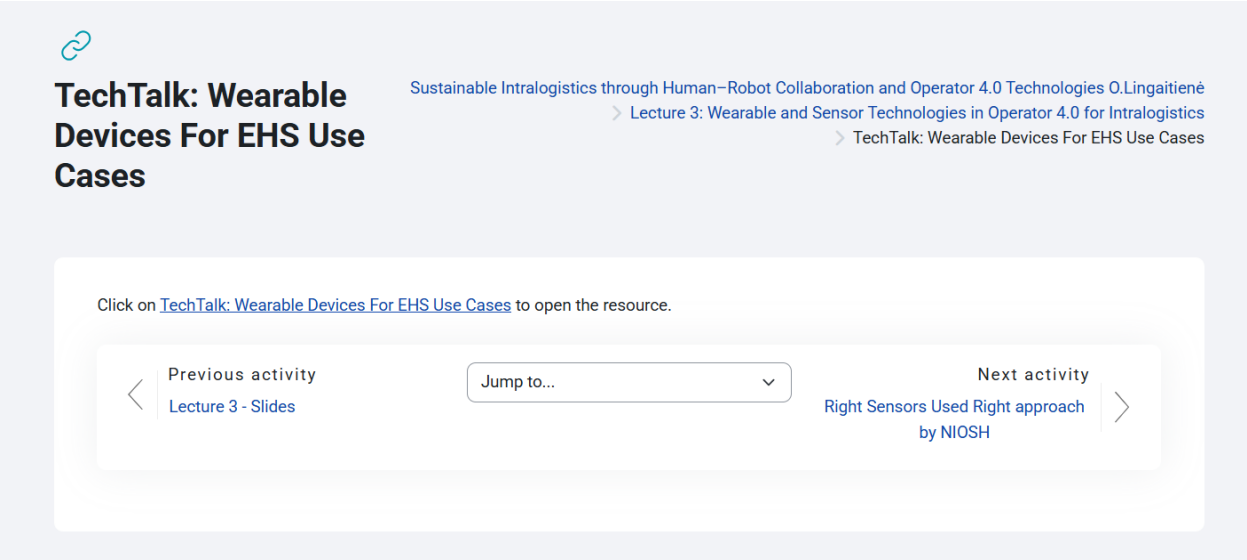

Figure 14. Example of External Resources

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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