SEUS
Smart European Shipbuilding

Funded by European Union

D5.5 - LEARNING TECHNOLOGY-BASED TRAINING

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Executive Summary

This report represents the development, original implementation, and evaluation of a digital learning solution created within the SEUS project to promote smart European shipbuilding. Smart European shipbuilding requires digitalisation skills development for personnel in shipyards as well as shipbuilding knowledge development for personnel in software firms. To address critical skill areas like digital tool usage, data-driven methodologies, sustainable team operations, and product lifecycle management related workflows, this learning resource was developed based on the Human-Centric Competency Model for Shipbuilding. A blended design approach was used to shape the learning experience rather than relying on a single instructional model. Up-to-date instructional development tools and approaches were combined to ensure pedagogical alignment, accessibility, and contextual relevance.

Human-centric learning solution development required direct involvement with personnel from shipyards and software firms and intensive cooperation between SEUS research teams. Design-Based Research (DBR) methodology uses iterative development cycles with integrated stakeholder evaluation, and each development cycle is used to enable the following scientific stages during the material development. The DBR process yielded a **four-module digital learning solution “Data-Driven Shipbuilding”** which is highly visual, interactive, supported with voice and textual guidance, problem solving tasks, and learning assessment. A common learning module was created for all target groups, as the first educational module. The main part of the content structure comprised three role-based learning modules for selected target groups in shipyards: managers, supervisors, and designers/engineers. The modules encourage quantifiable knowledge acquisition and learner engagement through the use of instructional prompts, interactive visuals, formative and summative feedback, and real-world scenarios.

Altogether nine testing and training events were organised with participants from educational institutions and SEUS partner firms. Evaluation data were collected through repeated interviews and surveys with target groups after each implementation. The analyses revealed that refinements in each solution version significantly improved user experience, clarity of technical content, interface usability, and contextual applicability. The feedback of participants guided major revisions, such as interface redesign, clearer guidance mechanisms, enhanced feedback systems, and a restructured case study component based on real-world suggestions. The integration of these improvements not only demonstrated a high level of learner-centred responsiveness but also underscored the effectiveness of iterative, evidence-based design practices in technology-supported learning environments.

The entire course content is available as an open learning solution on the DigiCampus platform. This published pilot version represents knowledge at the time of the solution design. It is possible that the progress of the other work packages in SEUS project may suggest modifications later on.

Besides the main learning technology solution, an **instructive, interactive, and collaborative board game** concept was developed and tested to enable blended learning settings and a fun educational approach to strengthen shipyard target groups’ comprehension of the meaning and potential of digitalisation as part of the shipbuilding process. Additionally, **an augmented reality solution** was designed for promoting software professionals’ skills concerning different ship types and ship lifecycle.

This report highlights ways of using modern learning technologies specifically to drive digitalisation development in shipbuilding, while using a user-centric, interactive design approach to enable human-centric development. The modular and scalable structure of the training platform provides a future-proof foundation for industry-wide use. The SEUS learning technology solution “Data-Driven Shipbuilding” serves as both a functional resource and a transferable model for integrating online-based upskilling into the digital transformation of the European shipbuilding sector.

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1. Introduction

SEUS project seeks increased levels of digitalisation in European shipbuilding, and some of these pursued impacts can be achieved through human-centric knowledge development and promotion of workforce skills and expertise. Personnel's capabilities to use digital tools and systems require designing and developing publicly accessible learning materials that promote digitalisation skills among shipbuilding personnel. As workforce may differ in their motivations, competences, and digitalisation preferences, the learning technology solutions must address the diverse needs of different target groups. The creation of successful learning solutions must be directed by human-centric approaches in order to satisfy the demands of a complex industry such as shipbuilding, which brings together partners with a variety of expertise.

SEUS Task 5.5 focuses on providing learning technology-based training for skill development in the shipyards by deploying a human-centric competency approach and implementing a systematic process to design and develop the learning material. Task 5.6 concerns the knowledge and skills development of software developers. The targeted competency dimensions include shipbuilding processes, digital tools and data literacy, metacognitive knowledge and skill acquisition, as well as collaboration and interaction among stakeholders. The development process proceeded from learning needs analysis through design and development, to testing and feedback collection, to ensure that the desired learning outcomes are achieved. While the learning resources are publicly accessible for professionals, students, hobbyists and anyone else interested in data-driven development of shipbuilding, SEUS consortium members and students were the primary audience during the initial deployment. The European shipbuilding industry may strengthen internal capacity, gain new partners, and enhance its competitive edge in the global maritime market through enriched knowledge and workforce capabilities.

The development of human-centric learning materials in tasks 5.5-5.6 relies on sound instructional design principles. We used widely-used principles and frameworks in the learning solution development, such as:

- **Structuring the learning solution and its materials**: ADDIE model with five iterative stages - Analysis, Design, Development, Implementation, and Evaluation (Molenda, 2015),
- **Setting learning objectives in line with industry expectations**: SMART criteria - Specific, Measurable, Achievable, Relevant, Time-bound (Wolf & Akkaraju, 2014),
- **Embedding formative and summative evaluations to drive continuous improvement:** Morrison, Ross, and Kemp (MRK)'s flexible and iterative instructional design model (Morrison et al. 2019),
- **Selecting appropriate media and learning techniques for different learners:** CRAMP model - Comprehension, Reflex Skills, Attitude, Memorisation, Procedural Learning (Romizowski, 2013), and
- **Enabling easy, open, online access to the learning technology solution**: use of a MOOC (massive open online course) platform to enable broad availability and access.

This report presents the learning technology solution development process and outcomes following the stages of the ADDIE model. The report content is supported with additional details and visuals provided in the appendices. The next section focuses on the learning needs analysis to determine the target audiences and their learning preferences. The design section outlines the learning objectives and content structure as well as the development stages that describe the tools and techniques used to produce the materials. The fourth section focuses on the iterative design process that tests the developed material, gathers feedback, revises the material, and repeats this cycle until reaching expected outcomes. The evaluation section represents the findings regarding the collected data. The last section discusses the chosen delivery methods and dissemination strategy for the learning materials.

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2. Requirements Definition and Competency Needs

A learner analysis was conducted to uncover the specific learning needs, preferences, and challenges experienced by the shipyard stakeholders as the target audience. Three main approaches were used in collecting and analysing the data required for developing the solution: (1) an analysis of the total of 36 document-based materials, (2) qualitative questionnaires and interviews with 17 consortium members, and (3) unstructured interviews with five experts.

The interviews revealed a need to delimit the scope of the learning solution to selected few target groups who need and use digital technologies, have access to digital tools, and may act as the early users of digital solutions. Specifically, the consortium decided to target the learning solution at **designers and engineers, managers, and supervisors** who work at shipyards, and **software developers** both in shipyards and in information technology/software firms cooperating with shipyards. Other target groups were excluded due to the manual nature of some workers, their limited access to digital tools, and the overall level of digitalisation on shipyards currently. The scope, feasibility, and impacts of the learning solution development were optimised through designing a shared general module and three modules for designers and engineers, managers, and supervisors.

Table 2.1 summarises the user-centric comparison of focal learner types, roles, current knowledge and skills, learning preferences and challenges for each determined learning solution target group in the shipbuilding industry. Additionally, learning needs, gaps and potential motivation of stakeholders to adapt data-driven systems into their work environment are presented in Appendix Table A.1, which also includes the initial learning objectives considering the SMART criteria.

Table 2.1. Roles, skills, learning preferences and challenges of the shipbuilding personnel

Learner type	Primary role	Current skills	Learning preferences	Challenges
Engineers and Designers	Ship design and engineering processes	Proficient in traditional design but unfamiliar with data-driven digital tools	Structured, detailed content with a focus on practical applications	Integrating unfamiliar digital systems into established workflows
Supervisors	Oversee operations, ensure team efficiency	Experienced in the field and work processes, needs understanding of digital tools impact	Strategic insights, case studies, leadership development programs	Understanding technical aspects of new systems, aligning tools with strategies
Managers	Oversee operations, optimise workflows	Experienced in project management, needs understanding of digital tools impact	Strategic insights, case studies	Understanding technical aspects of new systems, aligning tools with strategies
Software developers	Developing software solutions	Familiar with technological tools, needs to understand shipbuilding terminology in particular	Technical, learning by doing, detailed content focused on terminology and systems integration	Comprehending a new terminology and analysing the requirements of the shipbuilding systems to integrate them to develop software solutions

Being human-centric is essential to reach the desired learning outcomes of the learning material. Therefore, the consortium members were actively included to determine their learning preferences. A total of 17 consortium members participated in the survey, representing eight organisations. Of the participants, 23% (n=4) were from the University of Turku, 17% (n=3) from GONDAN, 17% (n=3) from NTNU, 12% (n=2) from ULSTEIN, 12% (n=2) from SARC, and 6% (n=1) each from CADMATIC and CONTACT. The professional frequency of the participants is presented in Appendix Figure A.1 (a).

The participants highlighted the need for a platform for collaboration and practical knowledge sharing, particularly enabling peer-to-peer learning without overburdening the most experienced users. To "develop

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learning technology solutions that are up-to-date and realistic for the shipbuilding industry," they emphasised the significance of user-friendly tools. The participants stressed the necessity of real-world examples to make the learning process effective and relatable. They emphasised the necessity of enhancing the comprehension of platform users and intercommunication infrastructures. They also demanded that a bridge be built between the shipbuilding industry and software developers, assisting the latter in better understanding shipbuilding jargon and guaranteeing that digital solutions are in line with the industry's practical realities.

As seen in Appendix (Tacgin & Martinsuo, 2025a; Tacgin & Martinsuo, 2025b), Figure A.1 (b), 64.7% of the participants (n = 11) preferred a blended learning solution as a learning mode. Despite the focus on digital learning solutions, the second most preferred solution was face-to-face learning (n = 6), with one participant particularly emphasising the benefits of workshops and seminars. The third preference was eLearning with teacher support (n = 4).

The most expected outcome, Appendix Figure A.1 (c), from the digital learning solution was to enhance the collaboration among the team members (n = 13) during a shipbuilding project. They also would like to reinforce their confidence to integrate new tools (n = 12) into their professional lives. The participants (n = 11) prioritised strengthening collaboration with their stakeholders. The increased efficiency and time-saving were the other most preferred items (n = 10) by the participants, and enhanced design accuracy (n = 6) and cost-saving (n = 5) followed these expectations.

The preferred learning tools are presented in Appendix Figure A.1 (d). eLearning and simulation emerged as the most preferred tools (n = 9). Seven participants selected interactive videos and quizzes, demonstrating their desire for dynamic, hands-on learning opportunities that let learners utilise their knowledge. The video was another frequently selected option (n = 6) before instant feedback (n = 5) that revealed the importance of receiving immediate guidance and address misunderstandings.

Participants' responses to open-ended questions on additional tools highlighted the importance of practical, interactive, and personalised resources. They suggested incorporating visual aids and ensuring the availability of updated interactive visual resources to enhance engagement. The inclusion of regular feedback options and problem-solving demo sessions was recommended to provide instant guidance and real-world application. Furthermore, they expressed interest in integrating modern technologies such as augmented reality. In response to further recommendations, participants emphasised the necessity of highlighting the advantages, such as increased competitiveness and the costs, such as time and effort, in order to more effectively encourage personnel and shipyards to embrace new technologies. They noted that the traditional nature of the industry might make some prefer familiar formats like paper and pictures, though these may not be the best solutions.

Appendix Figure A.2 provides a summary of the recommended learning methods and techniques that take into account the preferences of the target audiences in line with the literature and interviews conducted under the CRAMP model.

To sum up, engineers and designers must define and apply data-driven shipbuilding tools to optimise design by reducing iterations. This aligns with the Conceptualising (C) and Reflecting Skills (R) dimensions of the CRAMP model, suggesting the use of discovery-based learning. For complex, unsimplifiable tasks requiring skilled movement, a progressive part method should be used, teaching each part sequentially. Supplementing this with interactive CAD videos and modular hands-on tasks supports applied learning. Supervisors improve team performance through these tools, requiring both conceptual understanding (C) and attitude change (A). Depending on whether existing attitudes are to be built upon or replaced, case studies or role-playing are recommended, as well as scenario-based dashboards that support engagement. Managers use these tools to shorten project timelines, involving skilled tasks (R) and procedural learning (P). For simple tasks, checklists suffice; complex ones require algorithms or audio guidance.

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3. Design and Overview of the Learning Solution

This study used a design-based research (DBR) methodology to develop and refine an e-learning module for shipbuilding professionals. The DBR approach was chosen for its ability to link theory and practice through cyclical design, implementation, evaluation, and revision phases (Hoadley & Campos, 2022; Wang & Hannafin, 2005). This methodology enabled close collaboration with field experts and end-users while maintaining a strong emphasis on ID theory and evidence-based decision-making.

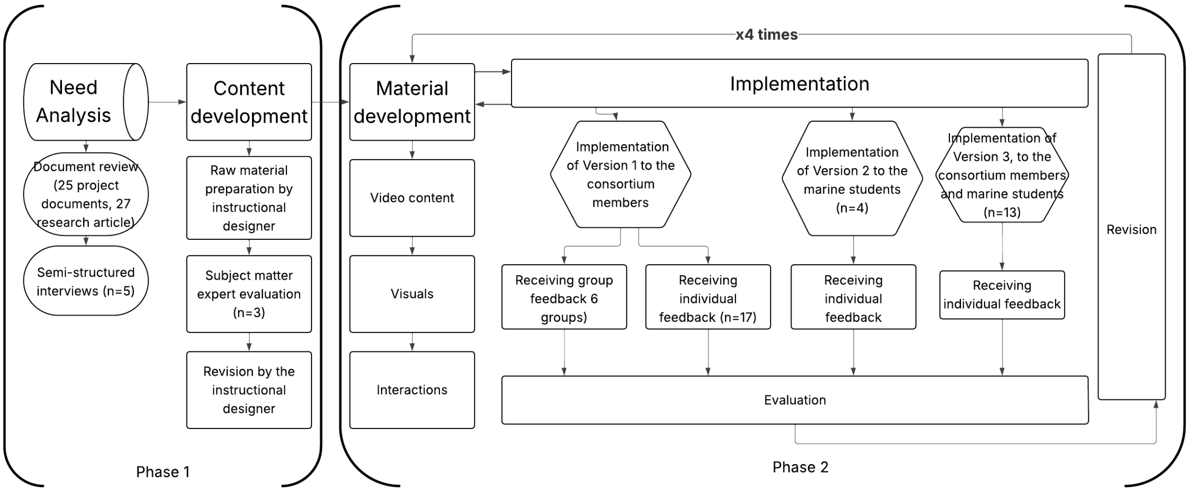

Figure 3.1. Material development process

At the design phase, learning objectives and content strategy, including selected media and learning activities, were defined for each target audience. Then, the instructional designer prepared the text-based learning content. Three subject matter experts reviewed all prepared learning materials to ensure terminological accuracy and content relevance. Each content item underwent at least three rounds of revision prior to the development phase, focusing on consistency, clarity, and alignment with shipbuilding-specific terminology. Three learning three learning components are designed, developed and tested to represent a blended learning environment.

3.1. eLearning modules and MOOC

Hyperlinks of the edited learning content for all modules are presented in Appendix B.

Following this rigorous review process, each module was developed using a combination of authoring tools, video editing software, image editing applications, and additional multimedia resources. This multi-tool approach enabled the creation of engaging and pedagogically sound learning modules.

The design components of all modules were developed within a consistent framework, adhering to core usability principles. Each module includes a set of common interactive features aimed at enhancing the user experience and supporting learning continuity. These features are:

- A glossary to facilitate understanding of key shipbuilding terminology,
- AI integration to enable further exploration and research on specific terms,
- Downloadable PDF resources for extended learning,
- A direct messaging function to contact subject matter experts, serving as a mentoring-like support mechanism.

In addition, the general user interface offers interactive elements such as a toggleable content tree and a slider-based control system that allows users to manage audio narration and subtitle options according to their preferences.

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An example of the general user interface layout used across all learning content is illustrated in Appendix Figure B.1.

Table 3.1 The main objectives, learning objectives, key focus and learning activities of each module

Module	Main objective	Learning objectives	Key focus	Learning activities
Common learning module	Understand the concept, benefits, tools, and integration of data-driven shipbuilding	Learners can define the terms of data-driven shipbuilding. Learners will be aware of data-driven tools to utilise them in their workflows.	Raising awareness about data-driven shipbuilding across the sector	Drill and practice Real-world examples
Engineers and designers	Define and apply data-driven tools to reduce design iterations	Engineers and designers can optimise design processes using data-driven tools to reduce the number of iterations and improve accuracy. Engineers and designers will be able to define data-driven shipbuilding tools to conduct a virtual design review within their existing CAD software, applying at least two data-driven optimisation techniques.	Optimising design processes using data-driven tools	Real-world examples Case study Drill and practice
Managers	Present and apply tools to streamline operations	Managers will be able to present a high-level overview of how data-driven shipbuilding tools can reduce project timelines and costs. Managers will be able to use real-time data from data-driven shipbuilding systems to monitor workflow performance and identify areas for improvement during a simulated team project.	Reducing project timelines and enhancing workflow	Short interactive videos Checklists Role-playing Demo
Supervisors	Enhance team performance using real-time data	Supervisors will be able to improve team efficiency by at least 15%.	Improving team efficiency and project	Short interactive videos Checklists Webinars Demo

A breakdown of the quantity of developed learning materials across the four modules is provided in Appendix Table B.1.

Sample visuals of various content types, including Video, Quiz Interface, Multiple Choice Questions, Drag-and-Drop Tasks, Open-Ended Questions, Case Studies, Real-World Examples, Demo, and Demo Activities, are presented in Appendix Figure B.2.

3.2 Board game

Moreover, considering the participants' preference for blended learning, and recognising that Universal Design for Learning (UDL) offers the most effective approach for such settings, we designed a board game to foster collaboration among team members and discuss the implications of digitalization affecting the phases of the shipbuilding process. The game was introduced and played during the face-to-face consortium meeting, where members actively engaged with it and provided positive feedback on its design and scenario. The game features seven different types of cards, including five role cards for engineers, designers, supervisors, managers, and supervisors along with challenge and bonus cards. It is designed for collaborative, team-based play, where each role card contains specific tasks, bonus opportunities, and rewards. Some of these tasks can be completed more effectively through cooperation with other team members.

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The objective is to complete a full round around the board, representing the shipbuilding process through its key stages: design, planning, manufacturing, assembly, and delivery. Each stage contains task, challenge, and bonus cards. An instruction manual was prepared and published to clearly outline the game rules. A screenshot of the game board is provided in the Appendix, Figure B.3.
Following the board game session, consortium members evaluated the accompanying digital learning material, providing valuable insights for further refinement.

3.3 AR application for software developers

An AR (augmented reality) application was also developed to increase software developers' familiarity with vessel types and the ship lifecycle. The fiducial marker-based AR application -ARShips- was built using the Unity Game Engine and includes eight markers, each representing a different vessel type: Cruise, Rescue, Ro-Ro, Passenger Catamaran, Offshore, Tanker, and Navy Ship.

Using the AR mobile app, users can scan 2D vessel images to reveal interactive 3D models. These models can be rotated, zoomed in, and zoomed out for closer inspection. Users can also listen to audio information about the selected vessel type, and they may activate or deactivate the user interface to view additional written information.

In addition, the AR app includes three fiducial markers that trigger videos introducing the main stages of the ship lifecycle: construction, implementation, and service & maintenance.

The fiducial markers and general interface of the app are shown in the Appendix, Figure B.4. This application was also presented at a conference (Tacgin & Martinsuo, 2025a).

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4. Trainings for Testing the Learning Modules

The implementation phase of the modules was carried out following the design-based research (DBR) approach, which emphasised iterative refinement informed by real-world use and user feedback. Altogether nine testing events were organised, to test the different learning modules. The initial version of the common learning module was piloted in a workshop with 17 consortium members who were divided into small groups and asked to engage with the content under guided conditions. During these sessions, participants provided both group-based and individual feedback for the product evaluation regarding content clarity, usability, and relevance to their professional roles.

The pilot implementation highlighted critical insights into the practical deployment of digital learning tools within shipbuilding contexts. Participants appreciated the modular structure, glossary, and feedback-oriented quizzes, but also raised issues related to user interface responsiveness, navigation, and the clarity of instructional prompts. These findings underscore the importance of technical reliability and onboarding clarity in digital learning environments.

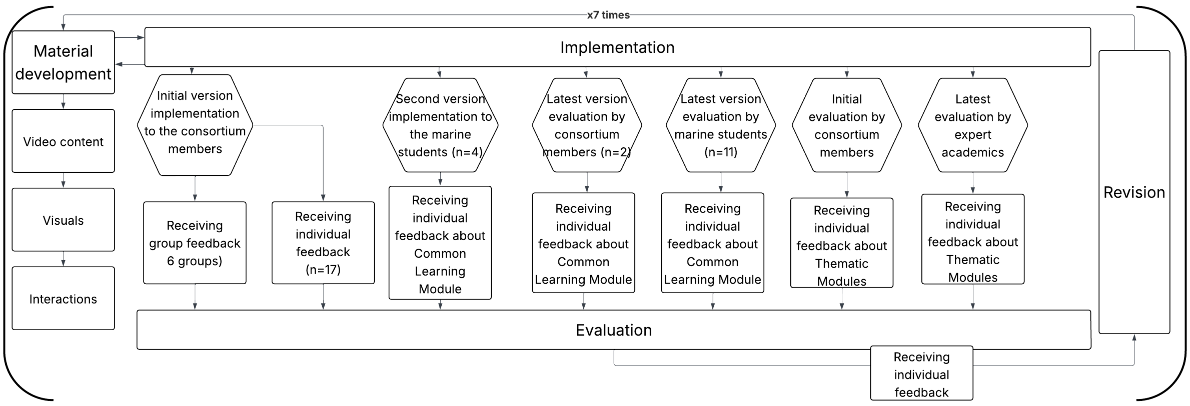

Figure 4.1 Implementation for Testing, Evaluation and Revision Cycle during Material Development

Following this initial rollout, a second round of implementation was conducted with four additional participants, who were marine engineering students currently working in the industry. Their feedback was instrumental in validating the effectiveness of the revised case study, enriched content, and interface improvements. Notably, the updated version received more positive responses regarding realism, readability, and interactivity.

After final revisions, the module was released to consortium members (n=2) and marine students (n=11) for a final evaluation cycle. This round confirmed that many of the earlier usability concerns had been addressed and that the learning experience had become more coherent and engaging. Participants were able to access the content through the DigiCampus MOOC (Massive Open Online Course) platform, enabling asynchronous learning and open access to the materials.

After completing the development of all modules, consortium members were invited to evaluate the thematic content based on their professional expertise. Two separate online sessions were organised to introduce the general structure of the MOOC platform, module flow, and certification system. The first session targeted engineers and designers, during which the features of the module tailored for their roles were presented to four consortium members within related professions and evaluation data gathered from them (n = 2). The second session was held for managers (n = 3) and supervisors (n = 2), focusing on the modules designed specifically for their needs.

Following each session, participants were given one hour by the instructional designer to explore the module independently and complete the material evaluation survey, accessible via the MOOC platform or

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at the end of each module. Participant feedback was then analysed and used to revise and improve the content before finalising the learning materials.

An additional evaluation session was conducted with academic experts from UTU and NTNU (n = 8). This session lasted for one face-to-face hour and an independent evaluation time for UTU researchers. NTNU researcher evaluated the modules independently. The participants completed the course content and provided detailed evaluations through DigiCampus, e-mail, notes, or survey forms.

The list of testing implementations of each module (Appendix Table D.1) is summarised in Table 4.1.

Table 4.1Testing groups and iteration

Tested Module	Duration (minutes)	Frequency (n)	Testing group	Type
Common Learning Module, version 1	60	17	Consortium members	Face-to-face
Common Learning Module, version 1	60	17 group evaluation (n=6)	Consortium members	Face-to-face
Common Learning Module, version 2	60	4	Marine students	Online
Common Learning Module, version 3	60	2	Consortium members	Online
Common Learning Module, version 3	60	11	Marine students	Online
Designers and Engineers, version 1	60	4	Consortium members	Online
Supervisors, version 1	60	2	Consortium members	Online
Managers, version 1	60	3	Consortium members	Online
All modules, latest version	180	8	Expert academics	Face-to-face & Online

Overall, the implementation phase demonstrated that structured piloting, combined with iterative user feedback, significantly enhanced the instructional and technical quality of the module. The process also revealed the necessity of clear role-based guidance, authentic case scenarios, and accessible design features to support digital upskilling in complex industrial environments like shipbuilding.

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5. Evaluation and Refinement of the Learning Modules

In line with the design-based research (DBR) approach adopted in this study, each version of the Common Learning Module was systematically evaluated and refined through iterative stakeholder engagement. Quantitative evaluations (on a scale of 1=totally disagree…5=totally agree) were supported by open-ended feedback collected via the Material Evaluation Survey. These individual and group-based responses guided several rounds of revision aimed at improving instructional clarity, interface usability, and perceived practical relevance. Below are the key results from the analysis:

As shown in Appendix Table D.1, we examined whether and how the more advanced training material versions differed from the early versions, using the Kruskal-Wallis test.

> *Finding 1: Kruskal-Wallis test revealed a statistically significant difference in material evaluation scores across the three module versions ($\chi^2(2) = 21.012$, $p < .001$), confirming the impact of progressive refinements.*

We assessed the quality of each version using 9 different themes, such as learning objectives, terminological correctness, user friendly interface, accessibility of UI components, engaging materials and activities, feedback on activities, concept reinforcement, practical scenarios, and visual design and readability. The overall mean rank scores were as follows: Version 1 = 11.18, Version 2 = 12.13, and Version 3 = 27.42. These results indicate that Version 3 was evaluated significantly more positively than the previous versions.

> *Finding 2: Marked Increase in Perceived Quality in Final Version: Participants rated Version 3 significantly higher (Mean Rank = 27.42) than Version 1 (11.18) and Version 2 (12.13), demonstrating improved alignment between learner needs and instructional design.*

We compared each evaluation theme between the advanced and early versions pairwise and found a statistically significant difference between groups, $\chi^2(2) = 21.012$, $p < .001$. To determine which specific pairs of groups contributed to this difference, pairwise comparisons were conducted using the Mann-Whitney U test. The results of these comparisons confirmed that the significant difference was primarily driven by the higher evaluation scores for Version 3 compared to Versions 1 and 2, as seen in Appendix Tables D.2, D.3, and D.4.

> *Finding 3: Pairwise Comparisons Validate Iterative Improvement: Mann-Whitney U tests indicated no meaningful difference between Versions 1 and 2 ($p = .928$), but statistically significant improvements between Version 3 and both earlier versions ($p < .001$ and $p = .010$, respectively).*

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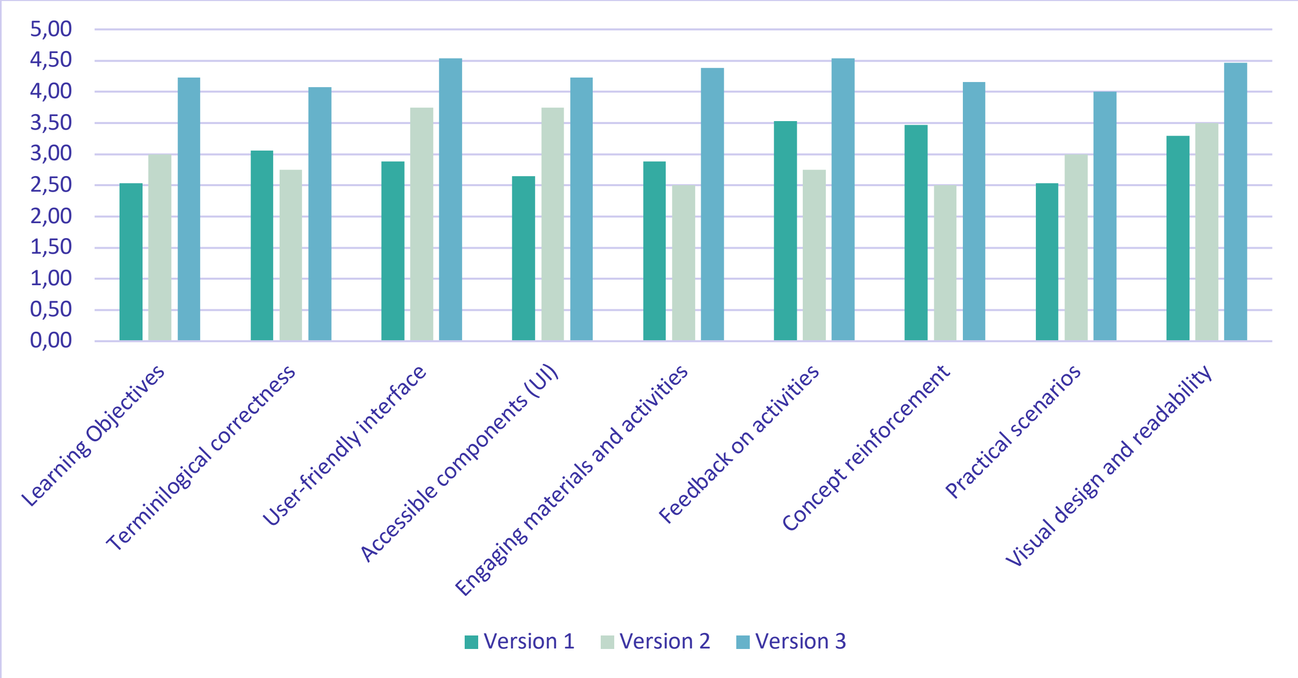

Figure 5.1 Item-based evaluation of the versions

The bar chart in Figure 5.1 presents the average ratings given to each item in the material evaluation survey, grouped by module version. It provides a clear comparison of how each version was perceived in terms of content alignment, technical terminology, user interface, interactivity, and overall design. As seen in the graph, Version 3 received notably higher scores across most items, indicating that the improvements made during the revision process were positively reflected in user experience. In particular, items related to interface usability and visual appearance show a visible increase, suggesting that the design updates were effective. On the other hand, the item about the use of technical terms shows relatively stable scores across versions, which may indicate that this aspect was already clear from the beginning.

Figure 5.1 and Appendix Figure D.1 demonstrate the effect of iterative revisions, showing a consistent improvement in learner satisfaction and perceived material quality.

These findings confirm that the iterative revisions, informed by both statistical evidence and qualitative insight, contributed meaningfully to the enhancement of the learning module. The following section outlines the major refinements made in response to these evaluations.

The multi-phase evaluation process, including both Likert-scale survey analysis and open-ended feedback, provided critical insights into how well the learning module met stakeholder expectations in terms of clarity, usability, and contextual relevance. Based on the open-ended feedback provided by participants in the material evaluation survey, a series of targeted revisions were implemented to improve the instructional clarity, usability, and contextual relevance of the Common Learning Module.

For the thematic modules, the evaluations provided by the relevant consortium members from each target group are shown in Figure 5.2. As seen in the results, after applying a human-centric design approach in the common learning module, the instructional components of the profession-specific modules (engineers & designers, managers, and supervisors) were rated positively for effectively delivering the required competencies by the end of the training. Moreover, participants shared open-ended feedback, highlighting specific technical issues in the learning material, such as overlapping audio, videos without sound, and unresponsive buttons. Thanks to this detailed input, all three modules were thoroughly revised and improved by the instructional designer.

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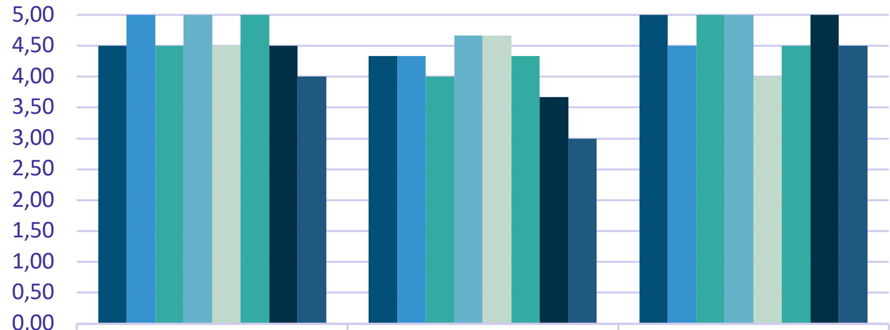

	Engineers & Designers	Managers	Supervisors
Average of Learning Objectives	4,50	4,33	5,00
Average of User-friendly interface	5,00	4,33	4,50
Average of Terminilogical correctness	4,50	4,00	5,00
Average of Engaging materials and activities	5,00	4,67	5,00
Average of Accessible components (UI)	4,50	4,67	4,00
Average of Feedback on activities	5,00	4,33	4,50
Average of Concept reinforcement	4,50	3,67	5,00
Average of Practical scenarios	4,00	3,00	4,50

Figure 5.2 The expert evaluations of the thematic modules

Finding 4: The importance of applying established design principles and conducting early user testing, as the successful integration of human-centric design in the initial module positively influenced the perceived quality of the entire training. Participants especially valued interactive components and responded more favourably to modules that reflected these tested, learner-centred approaches.

Participants' insights played a central role in shaping the iterative development process. One of the most prominent revisions was the redesign of the case study component. Initially criticised for lacking authenticity and industry relevance, the case section was entirely rebuilt based on a suggestion from a marine engineering student. The new case example reflects real-world operational challenges and is supported by hyperlinked resources to offer richer context and practical insight.

To enhance clarity and autonomy in interactive sections, short instructional prompts were added to guide learners through drag-and-drop and quiz-based activities. Instant feedback mechanisms were also revised to deliver more explanatory and constructive responses aligned with formative learning principles.

In response to usability issues raised by multiple participants, the interface was optimised with a new, more intuitive navigation structure. The problematic burger menu was removed and replaced with a clearly segmented layout. Caption sizes were increased to boost readability, and a colour-coded visual system was introduced to improve information processing, especially in sections covering categorical content.

The learning objectives of each module were revised to align with the SMART framework, ensuring that they were more Specific, Measurable, Achievable, Relevant, and Time-bound. Additionally, a new content section dedicated to Product Lifecycle Management (PLM) was added in response to feedback indicating a lack of clarity in this core concept.

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	Engineers	Managers	Supervisors
Average of Learning Objectives	4,50	4,75	4,50
Average of Terminilogical correctness	5,00	4,67	4,50
Average of User-friendly interface	4,50	4,00	4,00
Average of Accessible components (UI)	5,00	3,75	4,50
Average of Engaging materials and activities	4,50	4,00	5,00
Average of Practical scenarios	5,00	4,25	4,00
Average of Visual design and readability	4,50	4,25	4,00

Figure 5.3 The academic evaluations of the thematic modules

At the final stage, all modules were released on the LMS platform DigiCampus, and separate review URLs were generated to enable testing by academic experts. A total of eight academics and researchers participated in the evaluation, and the results are presented in Figure 5.3. In addition to the evaluation scores, detailed written and verbal feedback was provided. The feedback mainly addressed the scaling of text, improvement of video quality, consistency of feedback messages, and the trimming of unnecessary delays in videos and timelines. The instructional designer subsequently implemented all requested revisions.

These revisions demonstrate a strong commitment to learner-centred design and evidence-based development. By responding directly to stakeholder feedback, the learning material has become more inclusive, engaging, and aligned with the evolving needs of the shipbuilding industry.

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6. Delivery of the Learning Solution

To facilitate access to the complete learning set, including the modules, module evaluation surveys, certification, discussion forum, and additional features, an instructor account was created on the MOOC platform DigiCampus. This setup enables the course to be offered as open-access, allowing anyone interested in data-driven tools in the shipbuilding industry to benefit from the material.

DigiCampus is a Moodle-based learning management system originally developed for Finnish universities. The platform hosts a wide range of open courses across various disciplines. Each course is assigned a unique code and credit value to ensure validity and access control. While university-affiliated users can log in using their institutional credentials, other users can easily access the system using their Google accounts. For this project, a course titled **SEUS/MOOC: Data-Driven Shipbuilding** was created under the Multidisciplinary MOOC Courses section. Learners can access the platform via https://digicampus.fi and customise their dashboards based on their individual learning preferences after logging in to the system.

The course page on DigiCampus provides a general overview of the training content (Figure 6.1) for prospective learners. In addition, the platform's forum feature enables users to share feedback, ask questions, or initiate discussions related to the course topics.

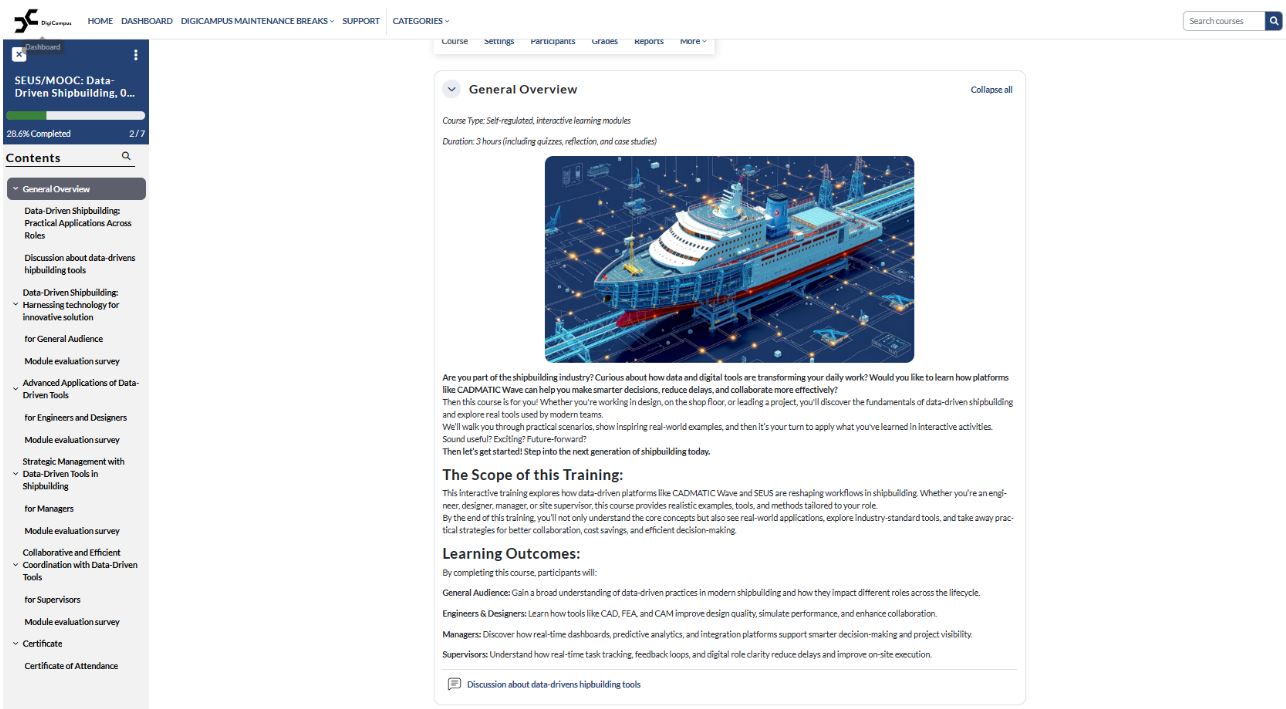

Figure 6.1. DigiCampus course page

Learners have the flexibility to complete all four modules in approximately three hours or to select individual modules based on their interests. At the end of each module, learners are invited to evaluate the learning experience by clicking the relevant feedback button embedded in the module (Appendix Figure E.2) or by accessing the evaluation survey available within the MOOC course interface (Appendix Figure E.1).

After completing the training, a course completion certificate is automatically generated for each learner by the system, as shown in Appendix Figure E.3.

Measurement and evaluation are essential components of any training environment, as they provide the foundation for understanding whether the learning process is effective. This learning set employs product evaluation by collecting data on usability, user interface, terminological accuracy, interaction, and design

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features through an end-of-module survey. However, this alone is not sufficient to confirm knowledge acquisition. To address this, each learning module includes both formative and summative evaluation components.

For formative evaluation, learners encounter various interactive elements such as drag-and-drop activities, matching tasks, multiple-choice, and open-ended questions embedded throughout the tutorials. These activities are designed to reinforce theoretical knowledge in real time. For summative evaluation, each module concludes with a drill-and-practice section, where learners are given targeted questions. If a question is answered incorrectly twice, constructive feedback is provided to guide the learner toward the correct response. The evaluation tools are listed in Appendix Table C.1.

All questions and quizzes were configured for tracking during the creation of SCORM packages, that is, a standardisation format of eLearning materials, allowing learner responses and success rates to be monitored directly via the MOOC platform.

Instructors on the Learning Management System (LMS) can access detailed activity reports, including time spent by each user on the training modules (Appendix Figure E.4). They can also review overall quiz results (Appendix Figure E.5) and download detailed answer data (in .csv or .xls format) to perform manual formative evaluations for each learner if needed.

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7. Conclusions

This report outlined the design, development and implementation of a comprehensive training solution aimed at meeting the general digital skills requirements of the shipbuilding sector. By employing a systematic and scientific approach, we make sure that the learning process is enhanced and aligned with the needs of real-world engineers, designers, managers, and supervisors.

This deliverable focused on three core objectives, all of which were achieved through a structured process. First, the organisation of multiple training sessions played a critical role in ensuring the effectiveness of the eLearning materials. We conducted nine sessions to test the materials, gather feedback, and make necessary revisions, ensuring the content met the learners' needs. This iterative process, based on direct user feedback, allowed us to keep the training relevant and effective.

The second objective, the creation of a human-centric competency model, was realised by actively involving consortium members and potential users throughout the design, implementation, and evaluation stages. Their input was essential in ensuring that the course materials were not only grounded in solid theory but also aligned with the practical competency needs of the learners. As a result, we developed an eLearning solution, a board game, and an augmented reality application for Android users to respond to the demand of participants regarding blended learning environments.

Lastly, the deployment of an open on-line modular learning solution on the Digicampus MOOC platform allowed for the realisation of the third goal, which was to offer open access to the learning resources. Anyone with a Google account could access this platform, which let students interact with the material at their own speed and obtain certification when they finished. By offering open access to the course, we have ensured that the training solution reaches a broader audience, thereby fostering digital transformation within the shipbuilding industry.

In conclusion, SEUS tasks 5.5-5.6 have successfully achieved its objectives by using a user-centred, scientific methodology. By integrating continuous feedback and a human-centric competency model, we have developed a training solution that is adaptable and effective. The outcomes of these tasks not only address the digital skills needs of the shipbuilding sector but also promote the long-term development of a digitally competent workforce, paving the way for sustainable innovation within the industry.

As SEUS project is still in progress, new knowledge and competency requirements may emerge later on through SEUS use cases and implementation of the integrated software platforms in the shipyards. Also, the deployment of the pilot MOOC solution “SEUS/MOOC: Data-Driven Shipbuilding” and collecting more feedback from its forthcoming users may generate new development ideas for any of the training modules and contents. The learning technology solution can be adapted, based on identified improvement needs, and further modules could be added to the solution.

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Appendix A. Used Instructional Design Models, Learning Objectives, and Survey Findings

Used Instructional Design Models and Principles

To meet the expectations of the shipbuilding industry, a blended instructional design approach was used, combining a number of instructional design models:

- The CRAMPS framework (comprehension, reflex skills, attitude, memorisation, procedural learning, and skills) (Romiszowski, 2013),
- The ADDIE model (analysis, design, development, implementation, and evaluation) for structured development (Molenda, 2015),
- The Universal Design for Learning (UDL) for accessibility and inclusion (Rogers et al., 2018),
- The MRK model for iterative, learner-centred design,
- SMART objectives (specific, measurable, achievable, relevant, and time-bound for clear goal setting) for learning objectives (Bjerke & Renger, 2017).

Learning objectives

The possible learning objectives, considering the SMART criteria, are written before designing the learning content. Table A.1 represents the distinguishing gap among the stakeholders in terms of the degree of awareness regarding the data-driven systems. Their role and responsibility also estimate the field of data-driven systems may contribute to optimising their performance.

Table A.1 Learning needs, gaps and potential motivation of stakeholders to adapt data-driven systems into their work environment

Learner Type	Gap	Need	Motivation
Engineers and Designers	**Lack of awareness** about how data-driven shipbuilding can enhance design processes	Understand practical applications of data-driven tools **to reduce design time, minimise errors, and foster creativity**	Faster design iterations, optimised performance, and innovative design solutions
Supervisors	**Limited access** to digital tools and integrating data-driven shipbuilding tools into work processes can cause a prejudgment approach	Learn to access and implement digital tools into workflows to **improve communication, decision-making and reach maximum productivity**	Smooth and successful production, improved team performance
Managers	**Limited understanding** of how digital tools can optimise workflows and lead to cost savings	Learn to adopt and integrate digital tools into workflows to **improve decision-making**	Cost and time efficiency, better decision-making
Software developers	**Lack of understanding** of shipbuilding terminology to develop modules and technical solutions for designers and engineers	Require training on the **shipbuilding terminology** as well as **the systems to simulate and test the designed products**	Gaining improvements and expertise in different disciplines

By the end of this training, potential stakeholders are expected to identify, optimise, present, and understand how to integrate the data-driven systems as revealed below:

- Every target group can define the advantages of data-driven shipbuilding tools and will be enthusiastic to embed these tools into their working routines.
- Engineers and designers can optimise design processes using data-driven tools to reduce the number of iterations and improve accuracy.
- Supervisors will be able to improve team efficiency.

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- Managers will be able to present a high-level overview of how data-driven shipbuilding tools can reduce project timelines.

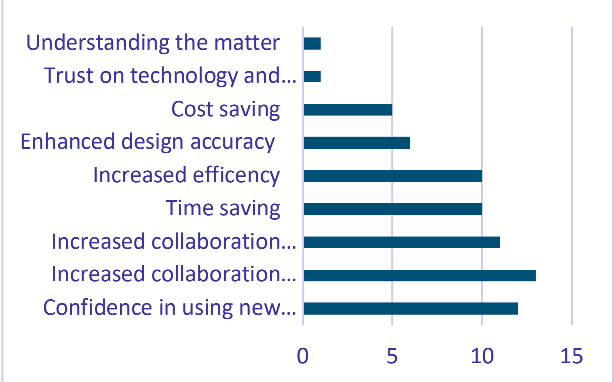
Learning preferences survey results

The findings regarding the survey results are summarised in Figure A.1.

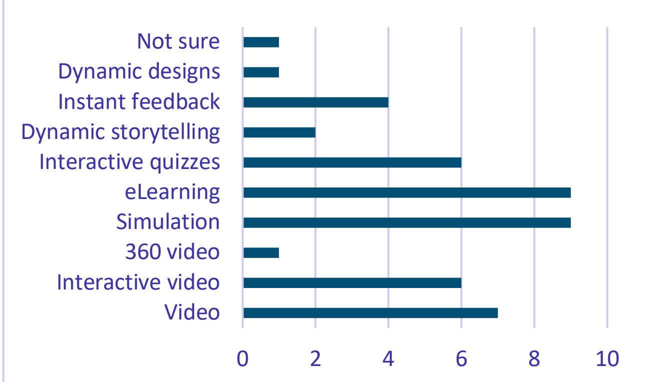
Category	Frequency
Naval Architect	4
Engineering	4
Management	3
Researcher	2
Consultant	1
Professor	1
Analyst	1

Professional distribution of the participants (a)

Preferred learning modes of the participants (b)



Expected learning outcomes of the participants (c)



Preferred learning techniques and tools by the participants (d)

Figure A.1 Survey results

Recommended learning methods and techniques

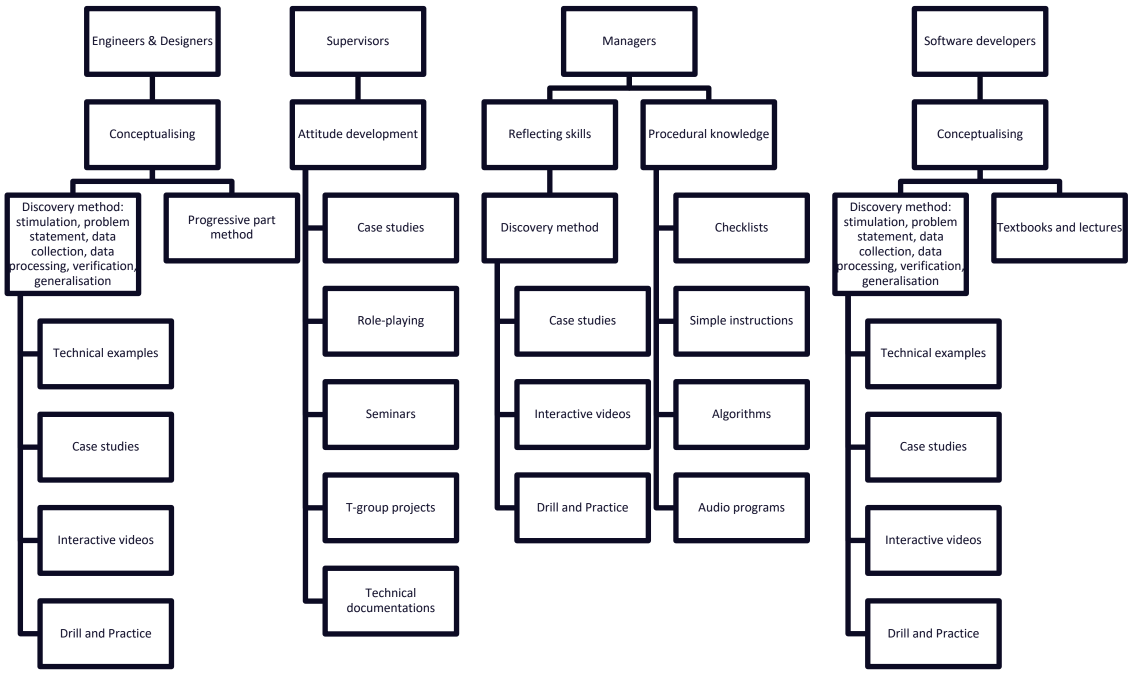


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Figure A.2 Suggested learning methods and techniques for the potential stakeholders considering the CRAMP model

Appendix B. Overview of the Learning Solution Content

Learning content

- Please click to see the revised version of the Common Learning Module Content for All Groups
- Please click to see the revised version of the Learning Module Content for Engineers and Designers
- Please click to see the revised version of the Learning Module Content for Managers
- Please click to see the revised version of the Learning Module Content for Supervisors

The features of general users interface

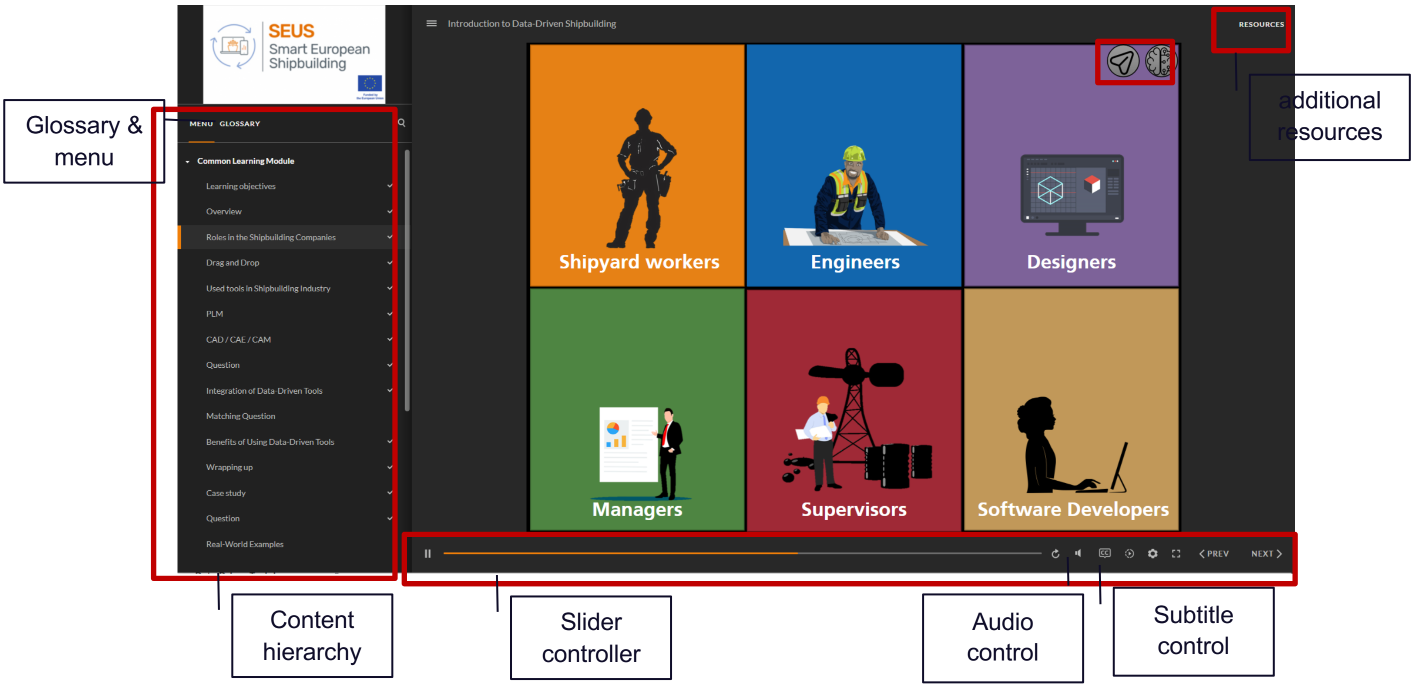

Figure B.1 The generic features of general user interface for all modules

Learning content

Table B.1. Frequency of materials among the learning modules

Type	Common	Engineers & Designers	Managers	Supervisors
Content Screen	19	23	17	17
Video	2	7	2	-
Quiz Screen	8	8	6	9
Multiple Choice Questions	5	8	3	4
Drag and Drop Questions	2	2	2	4
Open-Ended Questions	3	3	3	3
Case Studies	1	1	1	1

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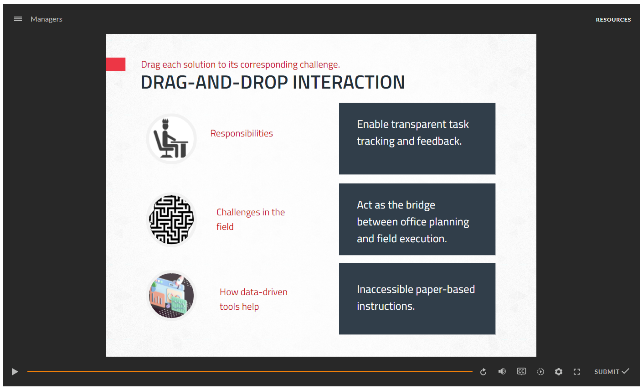
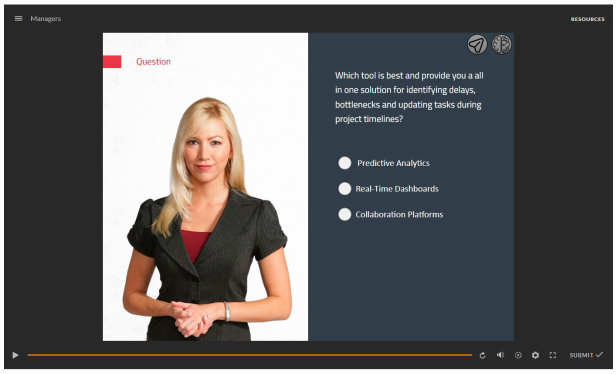
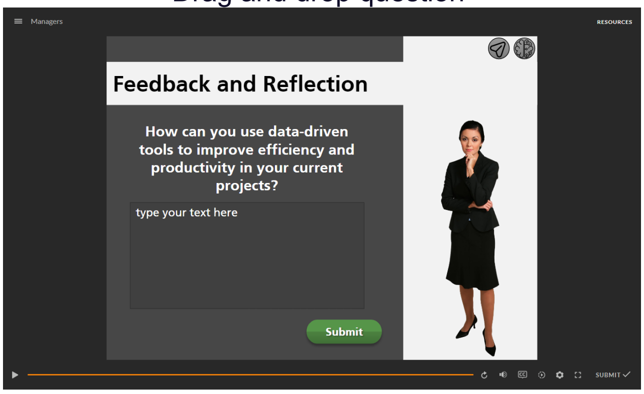
Real World Examples	3	3	3	3
Demo	-	2	1	1
Demo Activity	-	-	1	1



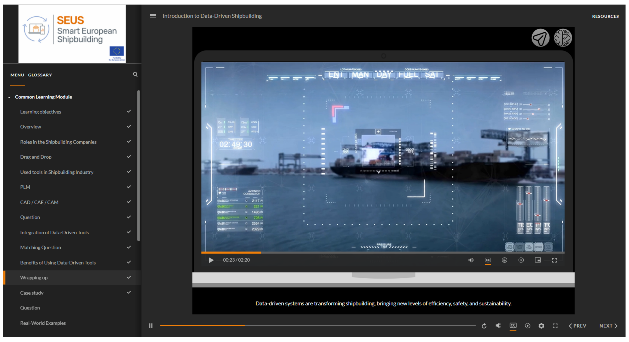
Drag and drop question



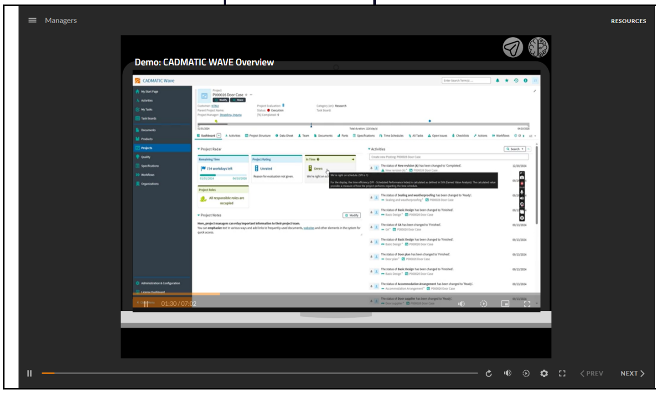
Multiple choice question



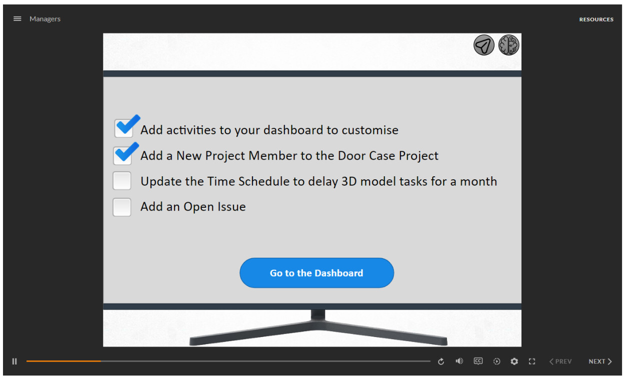
Open ended question



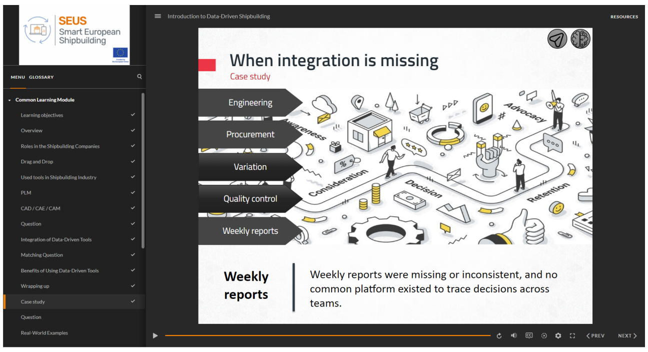
Video & captions



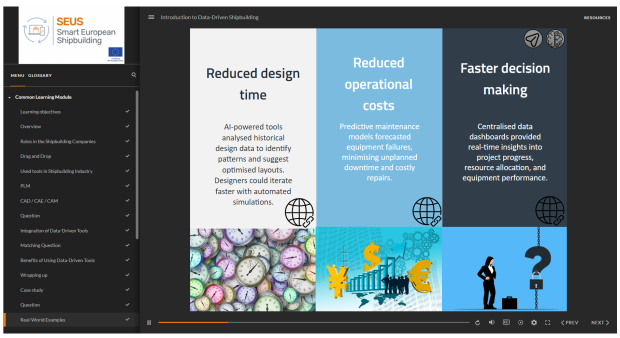
Demo tutorial



Demo activity



Case study



Real-world examples

Figure B.2. Sample screens on the eLearning solution

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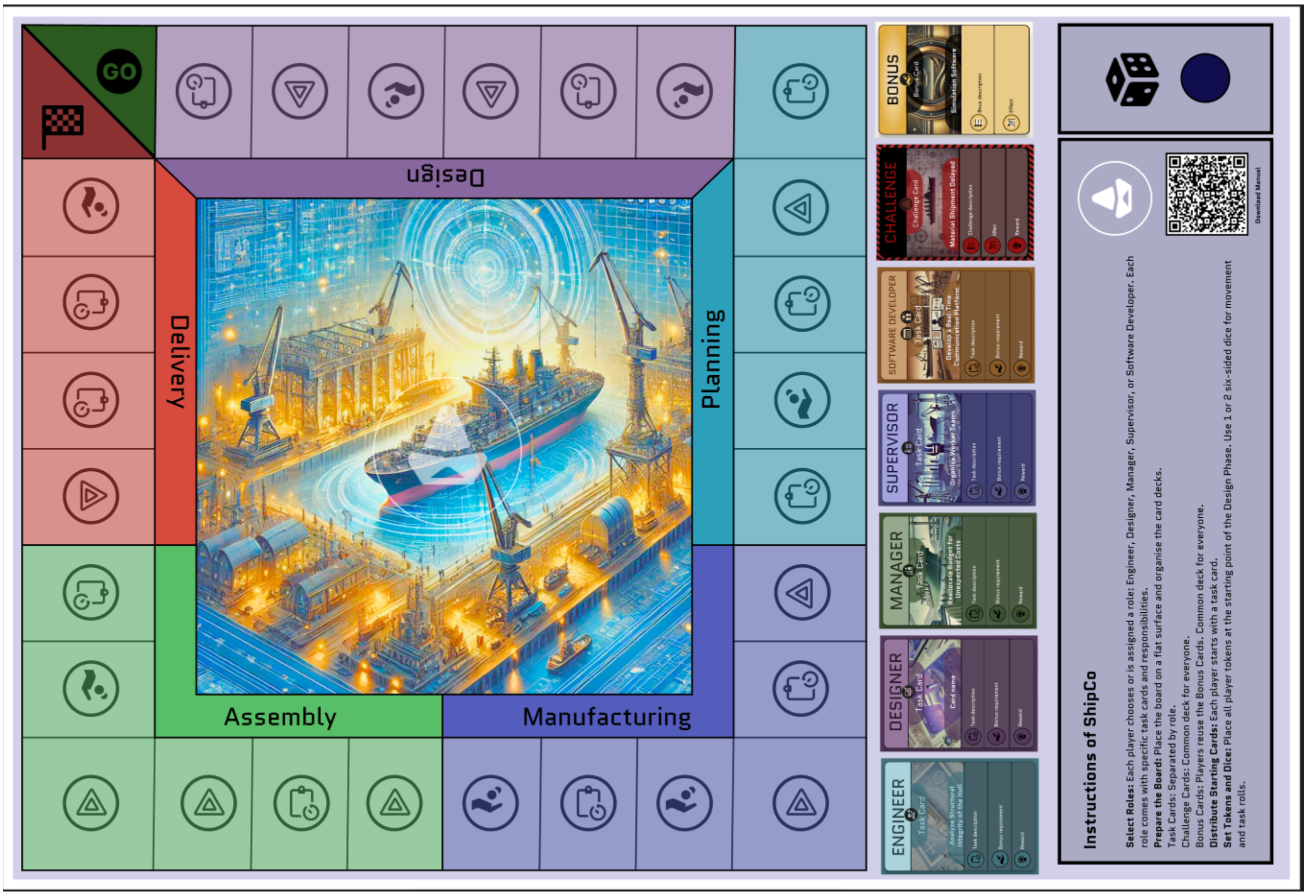
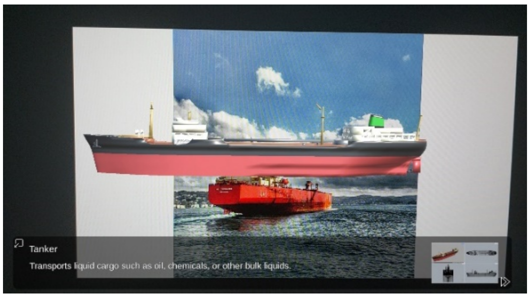


Figure B.3. Board game on the possibilities of digitalization in the shipbuilding process

Fiducial marker and 3D Tanker model

Fiducial market and for 3D Navy ship model



3D Tanker model with informative UI

3D Navy ship model with informative UI

Figure B.4. AR application on ship models

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Appendix C. Data Collection and Analysis

Table C.1 Data gathering tools

Tool	Item	Purpose
Learning preferences survey	4	Determining learning techniques and methods for the learning module
Open-ended questions	3	Receiving further information about learning preferences
Semi-structured interview	Minimum 6	Gathering information about the shipbuilding sector, learning implementations, learning needs, and roles
Material evaluation survey	9	Assessing content quality, usability, interaction, effectiveness, and design features
Open-ended questions	3	Gathering recommendations and interpretations regarding the material
Ill-structured material evaluation paper	N/A	Gathering group feedbacks

Table C.2 Most liked designed features by the participants

Design feature	Participants feedback
Glossary of Technical Terms	Described as ‘really great’, helped users understand complex terminology across different roles.
Video Captions and Playback Speed	Preferred for flexibility and learner control; users appreciated adjustable speed and captions.
Structured Objectives and Modular Layout	Helped with orientation and goal-setting; aligned with CRAMPS and SMART frameworks.
Interactive Quizzes with Instant Feedback	11 out of 17 participants agreed this feature reinforced learning through immediate feedback.
Platform Scalability and Flexibility	While usability issues were noted, participants saw strong potential if technical fixes were made.

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Appendix D. Evaluation Framework, Testing, and Results

Table D.1 Kruskal-Wallis results to compare the mean values among the versions of common learning module

Score	Groups	N	Mean		
Material evaluation	Version 1	17	11.18	21.012	<.001
	Version 2	4	12.13		
	Version 3	13	27.42		

Table D.2 Mann-Whitney Whitney-U results to compare the mean values of common learning module's version 1 and version 2

Version	N	Mean rank	Sum of ranks	U	z	p
1	17	10.94	186	33	-.09	.928
2	4	11.25	45			
Total	21					

Table D.3 Mann-Whitney Whitney-U results to compare the mean values of common learning module's version 1 and version 3

Version	N	Mean rank	Sum of ranks	U	z	p
1	17	9.24	157	4	-4.468	.001
3	13	23.69	308			
Total	30					

Table D.4 Mann-Whitney Whitney-U results to compare the mean values of common learning module's version 2 and version 3

Version	N	Mean rank	Sum of ranks	U	z	p
2	4	3.38	13.50	3.5	-2.568	.010
3	13	10.73	139.50			
Total	30					

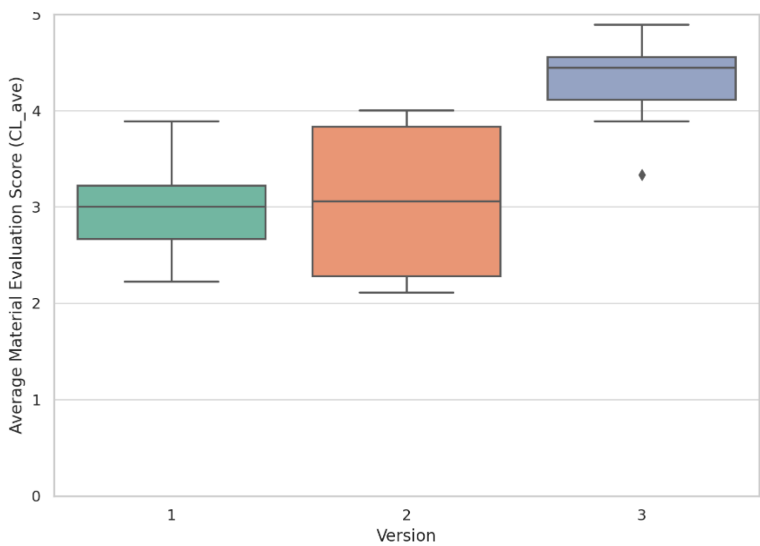

Figure D. 1 Material evaluation scores by version of common learning module

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Appendix E. MOOC features

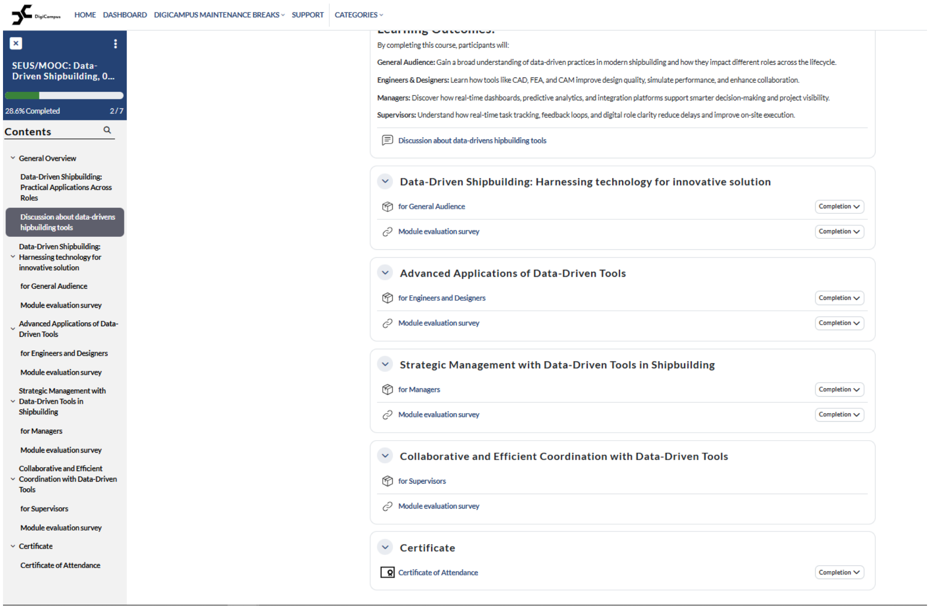

Figure E.1. Accessing learning content or evaluation surveys on DigiCampus

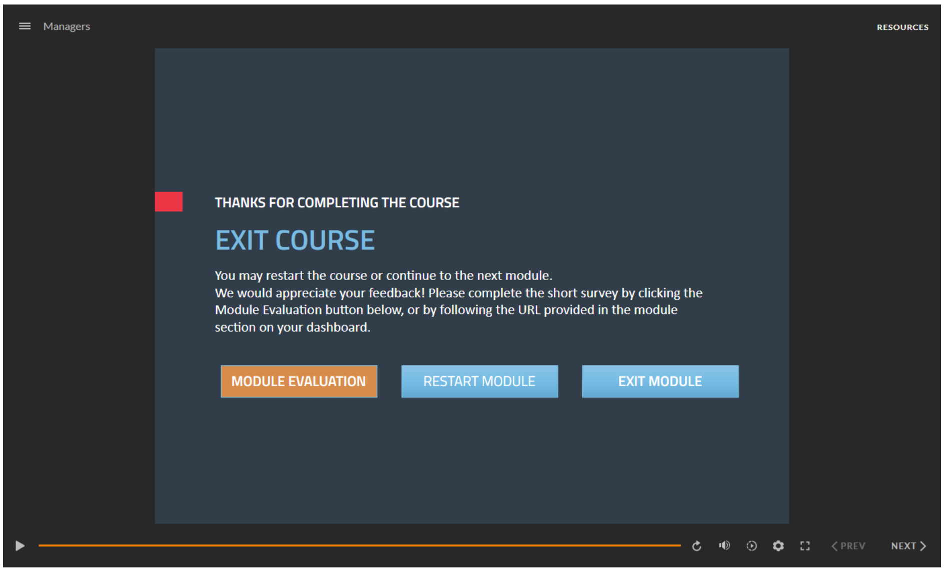

Figure E.2. Accessing the end-of-module surveys after the training

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DigiCampus

CERTIFICATE

Zeynep Tacgin Simsek

has completed the course

SEUS/MOOC: Data-Driven Shipbuilding, 0 cr, 2025

Date: 26.06.2025

Verification code: sU3bbWCJG7

Figure E.3. Sample certificate

Activity report

Filter

Computed from logs since Friday, 30 September 2022, 4:42 AM.

Activity	Views	Related blog entries	Last access
Discussion about data-drivens hipbuilding tools	-	-	
Data-Driven Shipbuilding: Harnessing technology for innovative solution			
for General Audience	26 views by 1 users	-	Thursday, 26 June 2025, 2:08 PM (2 hours)
Module evaluation survey	1 views by 1 users	-	Tuesday, 22 April 2025, 2:24 PM (65 days 1 hour)
Advanced Applications of Data-Driven Tools			
for Engineers and Designers	6 views by 1 users	-	Thursday, 15 May 2025, 11:42 AM (42 days 4 hours)
Module evaluation survey	-	-	
Strategic Management with Data-Driven Tools in Shipbuilding			
for Managers	5 views by 1 users	-	Wednesday, 25 June 2025, 5:24 PM (22 hours 43 mins)
Module evaluation survey	-	-	
Collaborative and Efficient Coordination with Data-Driven Tools			
for Supervisors	-	-	
Module evaluation survey	-	-	
Certificate			
Certificate of Attendance	5 views by 1 users	-	Thursday, 26 June 2025, 3:24 PM (43 mins 31 secs)

Figure E.4. Activity report

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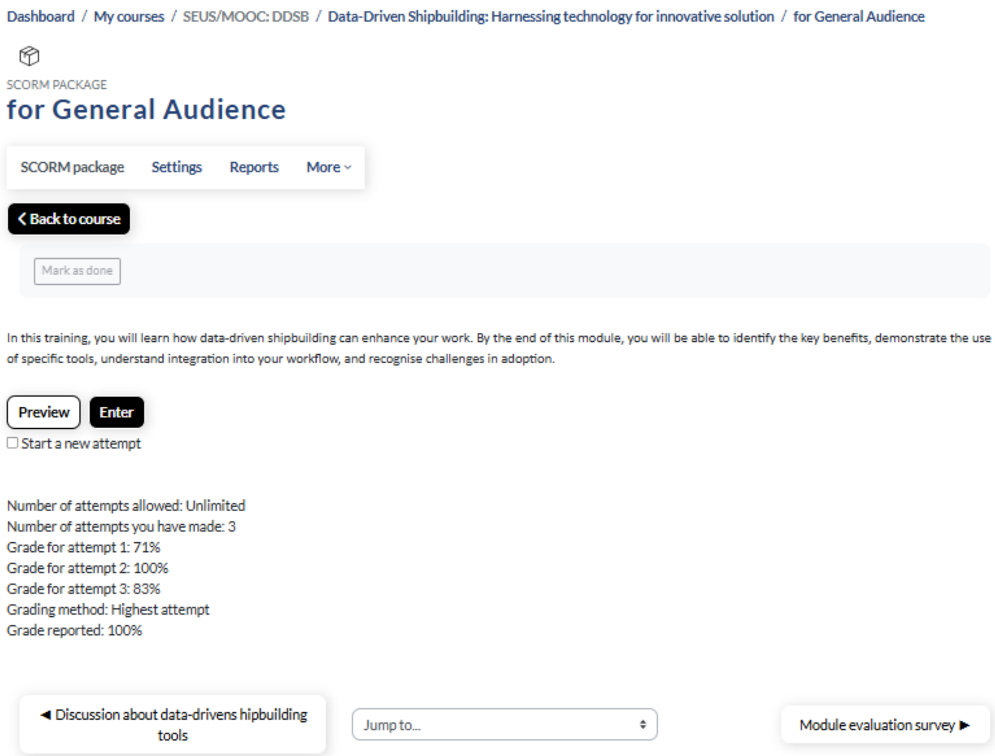

Figure E.5. Drill and practice results of a learner