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Empirical Research Paper

Developing a learning solution to promote digitalisation awareness and role-relevant knowledge in project-based firms

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ABSTRACT

Project-based firms increasingly rely on digital tools to manage complex projects throughout project lifecycles. Some digitalisation efforts may fail, as they do not account for differences in how experts and managers in various professional roles experience and adopt these tools. This study examines how a learning solution can be designed to address differing digitalisation awareness and role-relevant knowledge needs in project-based firms among engineers/designers, supervisors, and managers. Using an Action Design Research approach, we develop, implement, and evaluate a modular, role-sensitive learning solution in the context of European project-based firms in shipbuilding. The learning solution consists of a common learning module combined with role-specific modules tailored to engineers/designers, supervisors and managers. Iterative design cycles involved data collection through semi-structured interviews, a learning-preferences survey, a structured workshop, successive expert evaluations, and iterative piloting and refinement of the learning solution. The findings demonstrate that role-sensitive learning design enhances perceived relevance, clarity, and readiness to adopt digital tools across user groups. The study contributes design principles for developing learning solutions that support digitalisation, data-driven tool awareness, role-relevant knowledge, and readiness to adopt digital tools in complex project-based environments.

1. Introduction

Digitalisation is reshaping how projects are designed, coordinated, and delivered in project-based firms (PBFs). Digital tools such as enterprise resource planning (ERP) systems, product lifecycle management (PLM) systems, analytics solutions, and data-driven coordination technologies are becoming integral to project work, enabling enhanced information integration, simulation, and analytics across project lifecycles (Whyte, 2019; Whyte et al., 2016). Within this scope, digital information becomes an essential project deliverable, fundamentally shifting how work is organised and decisions are made in projects. Personnel in different job positions involved in PBFs need awareness and knowledge to use the digital tools effectively, which is the focus of this study.

Digitalisation developments and related competences are relevant in project-based firms characterised by high levels of complexity, customisation, and interdependence among multiple professional groups. Research on digital technologies in project settings has shown that digitalisation affects projects at multiple levels, including individuals, organisations, and inter-organisational networks (Papadonikolaki et al., 2022). Digital tools can support coordination across organisational and professional frames, and simultaneously reshape roles, responsibilities, and power relations within projects (Braun et al., 2025). As such, digitalisation is not only a technical change but a socio-organisational transformation that requires new forms of awareness and role-relevant knowledge development.

A fundamental challenge in digitalising PBFs lies in the heterogeneity of actors involved in project delivery. Even when the same digital tools are introduced across an organisation, their implications differ markedly across professional roles. Engineers and designers typically interact with digital tools as part of technical problem-solving and design workflows, supervisors use digital information to coordinate teams and monitor operational performance, and managers rely on digital data to support strategic decision-making and oversight (Papadonikolaki et al., 2022; Whyte, 2019). These distinguishing roles shape how digital tools are perceived, adopted, and integrated into daily work practices. Several digitalisation initiatives continue to rely on traditional training approaches that address these differences insufficiently, limiting the effectiveness of digital transformation.

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Prior research has revealed the growing significance of digital competences in project environments, as project management and delivery become increasingly data-driven (Liu et al., 2024; Marnewick and Marnewick, 2022). Moreover, studies on learning in PBFs highlight that competence development is situated, practice-based, and has a strong connection to specific work roles and project experiences (Kokkonen and Alin, 2015; Judgev and Mathur, 2013; Sense, 2008).

On the other hand, training opportunities in PBFs are limited because of the tight schedules and intense pressure to deliver the project requirements. Thus, completing the project is a priority rather than allocating time and resources to competence development. Empirical evidence shows that time pressure towards project completion and a short-term focus on deliverables can inhibit learning and knowledge transfer in PBF settings (Mainga, 2017). In such conditions, organisations may prefer simple and generic training materials because they are cheaper and easier to distribute. However, this is not enough in many cases. PBFs usually include people from different professional groups who use digital information for distinguishing purposes in their daily work. For instance, while engineers and designers focus on technical information, supervisors pay attention to coordination, and managers get down to decision-making. These differences make providing a single generic learning material harder to meet the learning expectations of each group. Therefore, learning solutions should move beyond tool-specific training and support broader digitalisation competences, such as awareness, attitudes, and readiness to adopt digital tools, through role-sensitive instructional design. There is a need to develop more knowledge on how learning solutions are designed to accommodate the diverse awareness and role-relevant knowledge needs of different user groups within PBFs. In particular, there is a need to move beyond tool-specific training to examine how broader digitalisation competences, such as awareness, attitudes, and readiness to adopt digital tools, can be developed through role-sensitive instruction design.

This study addresses this gap by examining the design of a learning solution to support digitalisation awareness and role-relevant knowledge development across distinct user groups in project-based firms. The aim is to demonstrate and offer new knowledge on role-sensitive learning design on digitalisation in PBFs. This research seeks to answer the following research question:

How can a learning solution be designed to address the differing digitalisation awareness and role-relevant knowledge needs of engineers/designers, supervisors, and managers in PBFs?

The study focuses on engineers/designers, supervisors, and managers that work in shipbuilding projects, representing a complex project-based setting where digital tools span the entire product lifecycle and affect multiple professional roles. To investigate the mentioned design challenge, this study adopts an Action Design Research (ADR) approach. ADR is well-suited for developing and refining learning solutions in close interaction with practitioners while generating transferable design knowledge (Sein et al., 2011). In line with ADR principles, the study develops, implements, and evaluates a modular learning solution designed to address role-based differences among engineers/designers, supervisors, and managers. Iterative design cycles are implemented, involving needs analysis, prototyping, pilot evaluation, and iterative learning solution refinement. Rather than focusing on the use of a specific digital tool, the learning solution targets digitalisation awareness and role-relevant knowledge at a general level, including conceptual understanding of digitalisation, perceived relevance for one's role, and confidence in integrating digital tools into project work.

The paper continues by analysing previous research on using digital tools in PBFs, the requirement of digitalisation awareness and knowledge, and related learning. The ADR approach is then described, covering the design of the solution to educate digitalisation competences for different target groups and PBFs in shipyards as the industry context. The overall structure and modules included in the massive open online course (MOOC) are then described. The results introduce the learning preferences in the target groups, evaluations of the learning solution, and final role-based evaluations of the modules. The study contributes to research on digitalisation and learning in PBFs by offering empirically grounded design knowledge on role-sensitive learning solutions. The findings provide guidance on how learning materials can be structured to support digital transformation in complex project-based environments for practitioners.

2. Literature review

2.1. Digital tools in PBFs

In PBFs, digital tools refer to information technologies that support the planning, coordination, implementation, and governance of projects across organisational and lifecycle boundaries. These tools range from lightweight applications, such as collaboration platforms and visualisation tools, to complex enterprise-wide systems that integrate data across multiple project phases and stakeholder groups (Marnewick and Marnewick, 2022; Whyte, 2019). Rather than being limited to single functions, digital tools in PBFs often mediate interactions between actors, structure information flows, and shape how project work is understood and performed. Recent research conceptualises digital tools not merely as neutral technical products but as socio-technical systems that influence project practices, decision-making, and inter-organisational relationships (Braun et al., 2025; Papadonikolaki et al., 2022). From this perspective, digital tools both enable and constrain action, requiring users to develop new ways of working and interacting with project information.

Empirical studies indicate that PBFs utilise a diverse range of digital tools to support project delivery. Toukola et al. (2023) identify over one hundred digital tools used in project marketing alone, highlighting the increasing fragmentation and diversity of digital tool ecosystems in project settings. Similarly, Toukola and Ahola (2022) categorise digital tools used for stakeholder participation, illustrating how tools are adopted to facilitate communication, transparency, and engagement across project networks. However, much of this literature focuses on peripheral or task-specific tools, such as communication platforms, visualisation tools, or stakeholder engagement applications. While these studies provide valuable insights into tool diversity and usage patterns, they tend to underrepresent core enterprise systems such as ERP systems, PLM systems, and building information modelling (BIM) that have extensive implications for project organisation and governance.

Enterprise-wide digital systems such as ERP, PLM, and BIM differ fundamentally from standalone or task-specific tools. These systems are designed to integrate information across the entire project or product lifecycle, linking design, production, procurement, operations, and maintenance (Whyte, 2019; Whyte et al., 2016). As a result, they influence not only technical workflows but also organisational structures, responsibilities, and coordination mechanisms. In construction and infrastructure projects, BIM has been shown to deliver boundary objects that facilitate collaboration across disciplines while simultaneously introducing new coordination challenges (Papadonikolaki et al., 2022). Similarly, PLM systems in engineering-intensive industries restructure how design data, changes, and decisions are managed across projects and organisational units. ERP systems integrate financial, logistical, and operational data, shaping managerial control and performance monitoring.

Because these systems cut across organisational and professional boundaries, their adoption affects multiple user groups differently. Engineers and designers engage with detailed technical data, supervisors rely on real-time information for operational coordination, and managers use combined data for strategic oversight. Moreover, such systems often extend beyond firm boundaries to involve suppliers, partners, and customers, further increasing complexity and competence demands (Whyte et al., 2016). Other studies have examined digital tools in megaprojects and complex projects, highlighting the growing role of data analytics, automation, and cloud-based systems (Wijayasekera et al., 2022). Yet, across these streams, there remains limited integration between discussions of digital tool adoption and the awareness and role-relevant knowledge requirements of different professional roles within PBFs.

The characteristics of PBFs, such as temporality, uniqueness of outputs, and reliance on cross-functional collaboration, create specific challenges for digital tool adoption. Unlike process-based organisations, where tools can be optimised for repetitive tasks, PBFs require digital tools that support flexibility, learning, and adaptation across projects (Papadonikolaki et al., 2022). As digital tools shape project coordination and decision-making, competence requirements extend technical skills. Users must understand how digital tools fit into broader project processes, how information is generated and interpreted, and how digitalisation affects roles and responsibilities. These requirements highlight the need for development approaches that address not only tool usage but also broader digitalisation competences as well as awareness, role-relevant knowledge, and readiness to engage with digital tools.

2.2. *Digitalisation awareness and role-relevant knowledge in PBFs*

Digitalisation competences refer to the knowledge, skills, and attitudes that enable individuals to engage with digital technologies in their work effectively. In project-based contexts, such competences encompass not only technical proficiency but also the ability to interpret digital information, collaborate through digital systems, and integrate digital tools into project workflows (Liu et al., 2024; Marnewick and Marnewick, 2022).

Part of competence formation relates with digital technology users' general digitalisation awareness and motivation. Digital awareness can be understood as the extent to which individuals are able to critically recognise and reflect on the opportunities, risks, and consequences of digital technologies across their work and everyday contexts (Brummer, 2025). In the present study, this concept is used to denote role-relevant understanding of why digitalisation matters in project work and how digital tools reshape tasks, collaboration, and decision-making. Liu et al. (2024) drew attention to the necessity to integrate digital mindsets, motivation, and awareness with projects and their management, besides digital knowledge and skills. They specifically propose research into the mechanisms underlying and driving digital competences. This view is also aligned with Marnewick and Marnewick (2022), who show that project management is still adapting to digitalisation and emphasise the need for continuous learning in response to digital transformation.

From the point of the user, digitalisation is felt through the introduction of new tools and systems that originate at the organisational level. According to research on technology adoption, adoption outcomes are influenced by users' perceptions of the technology's utility, usability, and relevance to their jobs (Marnewick and Marnewick, 2022). Misalignment between tool design and user needs can result in resistance or superficial use in project-based environments with high time constraints and role interdependencies (Chen et al., 2025).

It should be emphasised that digitalisation competences are role-dependent. The effective components of digital competence for an engineer differ from those required of a supervisor or manager. This role dependency underscores the need to move beyond one-size-fits-all competence frameworks and to consider how awareness, role-relevant knowledge, and readiness to engage with digital tools may also differ across roles. Research conducted in project settings reveals that users' experiences with digital tools are influenced by their role within the project and how they interact with other roles (Papadonikolaki et al., 2022; Whyte et al., 2016). This implies that efforts to develop competence should take into account how various users perceive, interpret, and engage with digital tools in their everyday work. Engineers and designers need knowledge and skills that help them use digital tools in technical workflows, keep track of design data, and facilitate problem-solving. While supervisors should look for knowledge and skills that help simplify teamwork, coordination, and oversight, managers seek knowledge and skills that enable strategic decision-making, performance monitoring, and alignment with the organisational goals (Liu et al., 2024).

Although these differences are recognised, current research offers insufficient direction on the systematic design of learning solutions to meet role-based knowledge requirements. This gap is especially clear in research that looks at how to put a system into place without looking at how different groups of users learn to use digital tools or how learning solutions can support role-specific awareness, knowledge, and readiness in relation to those tools.

2.3. *Learning the use of digital tools in project-based contexts*

In PBFs, the adoption of digital tools is often hindered by one-size-fits-all training that ignores the heterogeneous needs of different professional roles (Whyte, 2019). To address this, learning solutions must shift towards personalisation, an approach that tailors instruction to the specific context and readiness of the learner (Wozniak, 2020). In professional environments, this is closely linked to andragogy, where adult learners are most motivated when they perceive the immediate relevance of the material to their specific work tasks (Knowles, 1990).

A key theoretical framework for achieving this is Bloom's (1968) Mastery Learning Model. Mastery learning is built on the premise that nearly all learners can achieve high levels of competence if given sufficient time and the appropriate quality of instruction. Central to this model is the requirement that learners demonstrate a specific level of success, often a 70% threshold, before progressing to more complex material (Bloom, 1968). By implementing a modular structure that separates common foundational knowledge from role-specific modules (for engineers/designers, supervisors, and managers), a learning solution can ensure that all personnel achieve a shared conceptual baseline while receiving the personalised, role-relevant instruction necessary for their specific domain. Consequently, evaluating a solution based on mastery principles provides a reliable indicator of whether the material successfully bridges the gap between general awareness and the specialised, role-relevant knowledge required in complex project settings.

Research on learning in projects and PBFs emphasises experiential, practice-based learning embedded in project work (Brandi and Iannone, 2021; Poell et al., 2018). Recent studies highlight the potential of digital learning environments, simulations, and game-based approaches to support competence development in complex project settings (Jääskä et al., 2022). However, the literature focuses either on generic project management education or on isolated learning interventions, with limited attention to role differentiation and organisational context.

Table 1 summarises prior research at the intersection of digitalisation, learning, and project-based work. While existing studies provide valuable insights into digital tools, awareness, role-relevant knowledge requirements, and learning approaches, they reveal a lack of empirically grounded guidance on how learning solutions can be designed to address role-based differences in digitalisation competences within PBFs.

While prior studies have examined digital tools, related competences, and learning in project contexts, they tend to address these topics in isolation. The reviewed literature demonstrates that digital tools play an essential role in PBFs and that their adoption reshapes project work across roles and organisational boundaries. These studies suggest that learning in project-based contexts is not only role-dependent but also activity-dependent, as different forms of learning may be supported through different instructional approaches and task formats (Ninan et al., 2022). While digitalisation competences are recognised as critical for effective project delivery, existing research provides limited guidance on how learning solutions can be designed to support awareness, role-relevant knowledge, and readiness across role groups in PBFs. There is a clear need for research that integrates these streams by examining how learning solutions can be designed to support digital awareness and role-relevant knowledge development across

Table 1
Summary of previous research on learning digital tools, awareness, and role-relevant knowledge.

Reference	Context and research method	Learning task and solution	Key findings relevant to this study	Main gaps guiding future research
Brandi and Iannone (2021)	Review of workplace learning and human resource literature	Learning in the context of work	Workplace learning is embedded in work practices and shaped by the relationship between learning, work design, and organisational context	Does not address digitalisation in PBFs or role-specific learning design for digital tools
Haj-Bolouri et al. (2021)	ADR-based workplace learning study	Design and evaluation of an e-learning platform for workplace learning	ADR can be used to iteratively organise, design, and evaluate workplace learning solutions in collaboration with practitioners	Not focused on PBFs or digitalisation awareness across professional roles
Jääskä et al. (2022)	Experimental study in project learning	Game-based learning for uncertainty management	Experiential and interactive learning supports learning in complex project situations	Limited evidence on applicability across different organisational roles
Liu et al. (2024)	Survey-based empirical study of project professionals	Development of data-savvy talent in projects	Digital competences shape how project management practices evolve in data-rich environments	Focuses on competence outcomes, not on the design of learning solutions
Marnewick and Marnewick (2022)	Conceptual analysis of digitalisation in project management	Continuous learning as a response to digital transformation	Digitalisation fundamentally changes project work and requires ongoing competence development rather than one-off training	Does not address how learning should be designed for different professional roles
Ninan et al. (2022)	Literature review on learning in projects	Overview of learning activities and methods	Project learning requires a mix of formal and informal learning approaches	Role-sensitive learning design is not explicitly addressed
Papadonikolaki et al. (2022)	Systematic literature review in the built environment	Digital technologies in project delivery	Digital tools affect individuals, organisations, and projects differently	Learning and competence development remain underexplored in relation to the role differences
Poell et al. (2018)	Review of 10 years of empirical research across occupations	Employees' individual learning paths across occupations	Learning paths differ across occupational groups, indicating that learning needs and participation patterns are role-dependent	Does not focus on digitalisation or project-based organisational settings

heterogeneous user groups in PBFs. Addressing this gap requires design-oriented research that combines theoretical grounding with empirical evaluation, thereby motivating the ADR approach adopted in this study.

3. Methodology

3.1. Research approach and context

This study adopts an Action Design Research (ADR) approach to develop and refine a role-sensitive learning solution for digitalisation in project-based shipbuilding. In line with ADR, the artifact was shaped through concurrent building, intervention, and evaluation in collaboration with practitioners rather than through a linear build-then-test sequence (Sein et al., 2011). The study integrated expert feedback, pilot evaluation, and successive revisions throughout the development process. This enabled the researchers to generate both a practically relevant learning solution and transferable design knowledge in the form of role-sensitive design principles.

The main research artifact is a learning solution designed to promote digitalisation awareness, role-relevant knowledge, and readiness to adopt digital tools among personnel working in shipbuilding projects. Instead of focusing on the use of a specific digital system, this study examines how learning can be structured to support digitalisation readiness across heterogeneous roles in a project-based firm. The study therefore evaluates the design and perceived usefulness of the learning solution, whereas the direct measurement of competence acquisition is left for a later stage.

This research and material development was conducted within a research project aimed at supporting digital transformation in shipbuilding. Shipbuilding represents a complex project-based environment characterised by customised products, long lifecycles, and strong interdependencies among design, engineering, production, and management. The shipbuilding projects tend to be unique, large, complex, and of high value, and require the involvement of multiple stakeholders. The research involves shipyards, software firms that support shipyards' digitalisation processes, and university and research institute teams supporting the digitalisation transformation. The shipyards deliver ships to international customers, and they differ in their shipbuilding project scopes and ship types. The projects may contain both design and delivery, and various subcontractors are used in the projects. Digitalisation initiatives in this context affect multiple professional roles in the shipyards and require coordination across organisational boundaries.

This study focused on engineers/designers, supervisors, and managers because these groups were identified through expert discussions and early needs analysis (Tacgin and Martinsuo, 2025) as central in implementing new digital solutions such as PLM systems in shipyards, as the primary intended users of the learning material, and the core knowledge-intensive roles involved in digital, data-driven management in shipbuilding projects. They represent the design, coordination, and decision-making chain through which digital information is interpreted and acted upon in project delivery. In contrast, groups such as shipyard workers, production-floor personnel, owners, and other external stakeholders were excluded from the investigation because the developed learning solution was not designed for their task environments or digital tool usage patterns. The participant group was therefore purposively defined as a knowledgeable core-user sample rather than as a comprehensive representation of all occupational categories in shipbuilding.

Participants in the study were volunteer subject-matter experts affiliated with organisations participating in the project consortium. Participation varied across design phases in line with the iterative nature of the ADR process. Participants had diverse professional backgrounds within shipbuilding projects, including design, engineering, supervision, and management. This diversity supported the identification of both shared and role-specific learning requirements.

3.2. Design steps and overview of data

The study followed an iterative design process consistent with ADR. Data collection and artifact development were closely intertwined, with empirical inputs informing successive design decisions and revisions. Fig. 1 summarises the main steps of the ADR process.

As seen in Fig. 1, the two-phase process of this study adopts the ADR process. The first phase focused on problem identification and requirements analysis through document review and semi-structured expert interviews (Tacgin and Martinsuo, 2025). The second phase involved iterative material development, implementation, evaluation, and revision of the learning solution. The learning material was implemented and evaluated across seven iterative cycles, during which both group-level and individual feedback were collected and used to refine the artifact. Although presented in two broad phases for clarity, the process was iterative, with repeated feedback loops between development, evaluation, and revision. The findings of this research focus on how consortium members from different professional groups evaluated

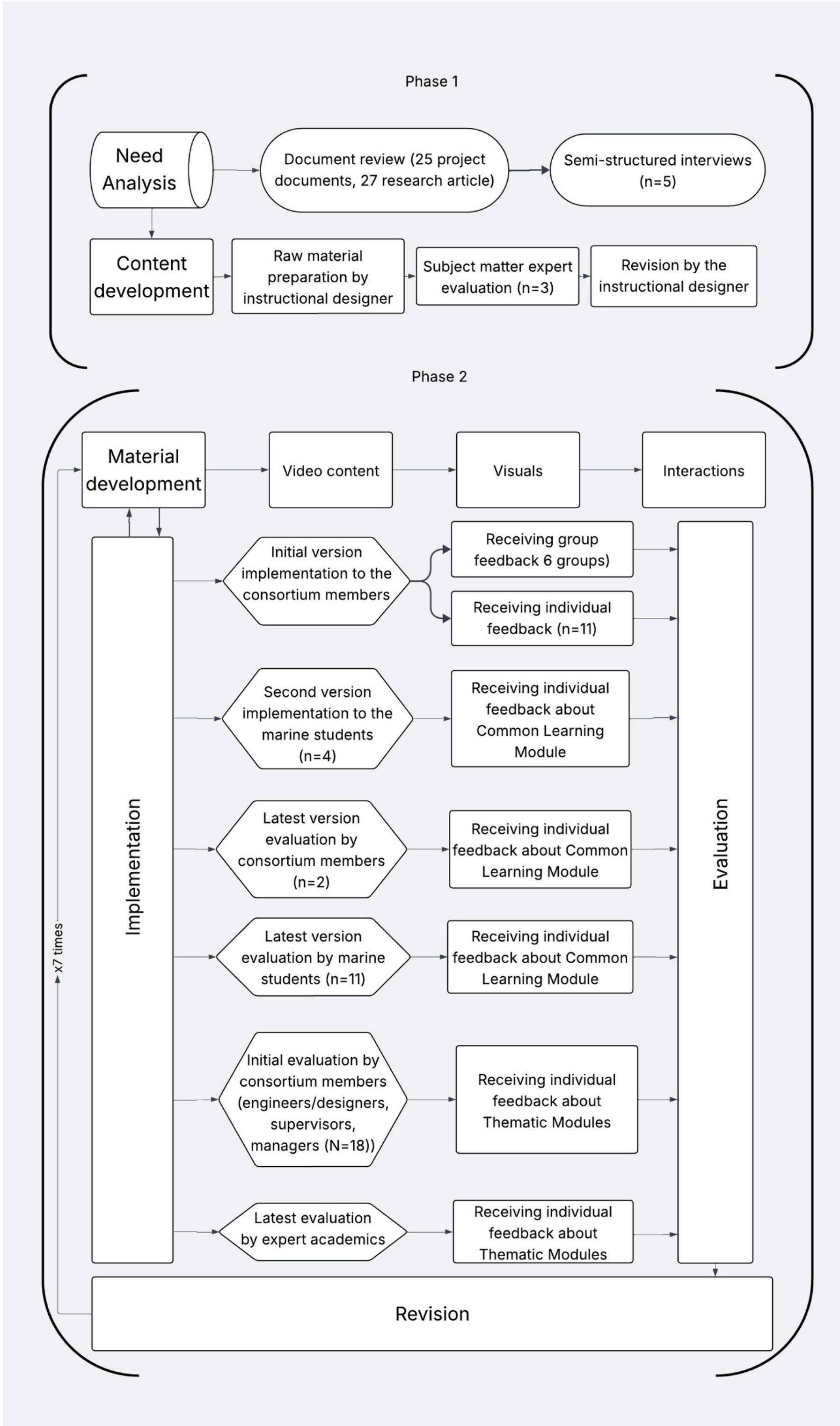

Fig. 1. Research process.

the thematic learning modules.

3.3. Data collection and iterative design process

Data collection was conducted within the research project and followed an iterative, expert-driven design process consistent with ADR. The data collection strategy combined qualitative and quantitative methods and was integrated with the design, development, and refinement of the learning solution. A core group of three subject-matter experts affiliated with the consortium participated voluntarily across multiple phases of this study.

In the early phases of the study, data collection relied on a knowledgeable cross-role expert sample to identify both shared and role-specific learning requirements, whereas role-specific differentiation was emphasised more explicitly in the final evaluation stage. Sequentially, interviews were conducted with five subject-matter experts (Tacgin and Martinsuo, 2025). Then, a learning preferences survey was administered to 17 subject-matter experts, including open-ended replies, to determine the characteristics of the proposed learning content. The prototype version of a module was assessed in a structured face-to-face workshop by 17 participants divided into six groups. The produced modules and materials were evaluated by three subject-matter experts in seven iterative rounds and were then amended by the instructional designer. Besides one general learning module, three distinct modules were developed for engineers/designers, supervisors, and managers. The final iteration of these modules was assessed and evaluated by five engineers/designers, five supervisors, and eight managers.

The data collection process proceeded in five iterative and partially overlapping stages. First, semi-structured interviews (N = 5) were conducted with subject-matter experts to explore digitalisation practices in shipbuilding projects, role-specific learning needs, and limitations of existing learning approaches. These interviews formed the basis for initial problem identification and requirements analysis, and their duration varied between 45 and 60 min.

Second, a learning preferences survey (N = 17) was administered to the volunteer consortium members, representing all research consortium member categories (shipyards, software firms, research institutions). The survey included nine categorical items as well as four open-ended questions, allowing participants to express their learning preferences, expected learning outcomes, and views on effective learning techniques. The results of this survey were used to determine essential andragogical approaches and design requirements for the learning solution.

Third, a face-to-face workshop (N = 17, again including all consortium member categories) was organised to evaluate the pilot version of a sample module of the learning solution. Participants worked in six small groups, reviewing the overall structure, andragogical approach, and key design features of the pilot material. Feedback from this workshop focused on the general design of the user interface (UI), clarity, usability, and perceived relevance of the learning solution.

Fourth, following the development of thematic modules, a subject-matter expert evaluation and material revision continued iteratively throughout the remainder of the project. Feedback from experts was systematically combined into the learning material, which was revised seven times as part of a refinement process led by the instructional designer. This phase ensured continuous alignment between expert insights and learning content as the solution evolved toward its final version.

Finally, three online group evaluation meetings were conducted with representatives from each target group to assess the final version of the learning solution. These meetings involved supervisors (N = 5), managers (N = 8), and engineers and designers (N = 5).

During these sessions, participants engaged with the role-specific learning modules and evaluated the material using a structured evaluation survey that consisted of nine Likert-type questions and three open-ended questions. This final evaluation phase provided the primary empirical basis for assessing how effectively the learning solution addressed role-based differences in digitalisation awareness and role relevant knowledge needs.

Data collection across all phases was carried out through online and face-to-face sessions, surveys, and document-based feedback, enabling triangulation across data sources and design stages.

An instructional designer was responsible for organising and synthesising the collected data and translating the findings into concrete learning material. This role ensured consistency in andragogical structure, systematic incorporation of expert feedback, and alignment between empirical insights and learning design throughout the iterative process.

3.4. Data analysis

Quantitative data from the learning preferences survey and the final evaluation instruments were analysed using descriptive statistics to identify patterns in participants' learning preferences and in their evaluations of the learning solution across role groups. Survey responses were transferred to Microsoft Excel and organised into structured tables to support analysis. Descriptive analysis focused on frequencies and percentages (e.g., distribution of professional backgrounds, preferred learning modes, expected learning outcomes, and ratings of the learning material, usability and effectiveness of the learning solution), and the results were summarised in tables and figures to provide an overview of patterns across participant groups. Given the exploratory and design-oriented nature of the study, these quantitative results were used primarily to support artifact refinement, and statistical generalisation was not pursued.

Qualitative data from the semi-structured interviews, open-ended survey responses, workshop discussions, and expert feedback were analysed using thematic analysis. The analysis proceeded iteratively across the ADR cycles. In the first stage, the researchers reviewed the qualitative material to identify recurring issues related to digitalisation relevance, learning needs, preferred learning features, and role-specific expectations. In the second stage, these initial codes were grouped into broader themes, such as shared learning requirements, role-specific needs, usability and interface issues, and perceived relevance of examples and activities. In the third stage, the themes were compared across participant groups and across design phases in order to identify both common patterns and role-based differences. Table 2 reports examples of the main themes used in the analysis.

As seen in Table 2, the resulting themes were used to inform successive revisions of the learning solution, including changes to terminology, examples, interface features, feedback mechanisms, and the differentiation of role-specific modules. Therefore, analysis was not treated as a separate step, but as a part of iterative artifact development.

Findings from different data sources and design phases were triangulated to inform iterative revisions of the learning solution and to support the abstraction of design knowledge regarding role-sensitive learning in PBFs. Triangulation involved comparing patterns emerging from survey summaries with themes identified in interviews and expert feedback, and using converging evidence to prioritise revisions. Based on this process, the learning solution was revised across development cycles, with content, visuals, activities, and role-specific emphasis updated in response to expert feedback.

4. Design and overview of the learning solution

The learning solution developed in this study was designed to promote digitalisation awareness and role-relevant knowledge among personnel working in project-based shipbuilding environments. Digitalisation awareness and role-relevant knowledge are understood to include not only knowledge of digital concepts, but also attitudes, awareness, and willingness to adopt digital tools in everyday project

Table 2
Coding structure and examples.

Data source (Example)	Initial code	Sub-theme	Aggregated theme
"I don't need the code, just the output." (Manager)	Information filtering	Role-specific relevance	Role-specific needs
"It's hard to find the right module." (Engineer)	Interface navigation	Platform usability	Usability issues
"We need a common language." (Workshop)	Terminological alignment	Shared understanding	Conceptual alignment

work. The design of the learning solution was guided by the recognition that different professional roles experience digitalisation differently, therefore, require differentiated learning support. Correspondingly, the learning solution was designed to meet two needs: (1) establishing a shared understanding of data-driven tools across roles, and (2) addressing role-specific awareness and role-relevant knowledge needs related to work practices, responsibilities, and decision-making logic.

4.1. Overall structure of the learning solution

The learning solution was implemented as a modular massive open online course (MOOC) hosted on a specific learning platform (DigiCampus). It consists of four modules: a common foundational module intended for all participants, and three role-specific modules, targeting engineers and designers, supervisors, and managers. Fig. 2 shows a simplified illustration of the structure and main features of the learning solution.

The common module provides a shared conceptual basis for understanding data-driven systems in shipbuilding projects, while the role-specific modules explain these concepts in role-relevant contexts, examples, and learning activities. This structure was chosen to support cross-role alignment while recognising heterogeneity in awareness and role relevant knowledge needs.

Once learners enter the course, they are first introduced to the purpose of all learning modules and the learning outcomes. An instruction is provided to help users understand how to navigate the course and use the learning modules effectively. When a learner selects a module, the multimedia learning material is launched. Each module follows a consistent interface standard to ensure a coherent learning experience. As seen in Fig. 2, a content hierarchy menu is available on the left panel, allowing learners to navigate between learning content and quizzes. Each module also includes a glossary. In addition, supplementary learning resources are provided in the top-right corner of the interface. Learners can submit personal feedback directly to the course designers or subject-matter experts. They can also connect to the research consortium's artificial intelligence solution to further explore topics in greater depth and support their individual learning needs.

Each module begins with a short introduction and a presentation of the expected learning outcomes. Audio narration is available across all modules, and learners may enable captions if they wish. The learning experience then continues with multimedia content, including instructional videos, interactive demonstrations, formative assessment questions, visuals, hyperlinks, and other interactive elements. The modules also present case studies and real-world examples, followed by a feedback and reflection section, a summary, and future directions. Each module concludes with a summative assessment, and both formative and summative assessments provide instant and constructive feedback. In line with Bloom's Mastery Learning Model, learners are expected to achieve a minimum success rate of 70 percent to demonstrate mastery of the learning objectives (Bloom, 1968). Evaluation activities include multiple-choice questions, drag-and-drop, list and matching exercises, and scenario-based open-ended questions. At the end of each module, learners can view their results, review correct and incorrect answers, and retry the quizzes if they wish. After completing a module, it is expected that learners complete a short survey to provide feedback for the sustainable development and continuous improvement of the learning material. This survey is accessible both at the end of each module and from the main course page.

These features were selected based on findings from the learning preferences survey and expert feedback (Tacgin and Martinsuo, 2025). Emphasising learner control (e.g., playback speed, captions), clarity of structure, and instant feedback were consistently highlighted as valuable during evaluation activities.

All modules were designed for asynchronous use, allowing participants to engage with the content at their own pace. The learning solution was delivered online, reflecting the distributed and time-constrained nature of work in PBFs.

4.2. Common foundational module

The common module introduces key concepts related to digitalisation in project-based shipbuilding environments. Its purpose is to establish a shared vocabulary and mental model across roles, reducing misunderstandings arising from role-specific interpretations of digital tools and data. Content in this module focuses on the role of digitalisation in complex project environments, the value of digital information across the ship product lifecycle, basic principles of data-driven work and system integration, and the implications of digitalisation for collaboration across roles.

The module emphasises why the integration of data-driven tools

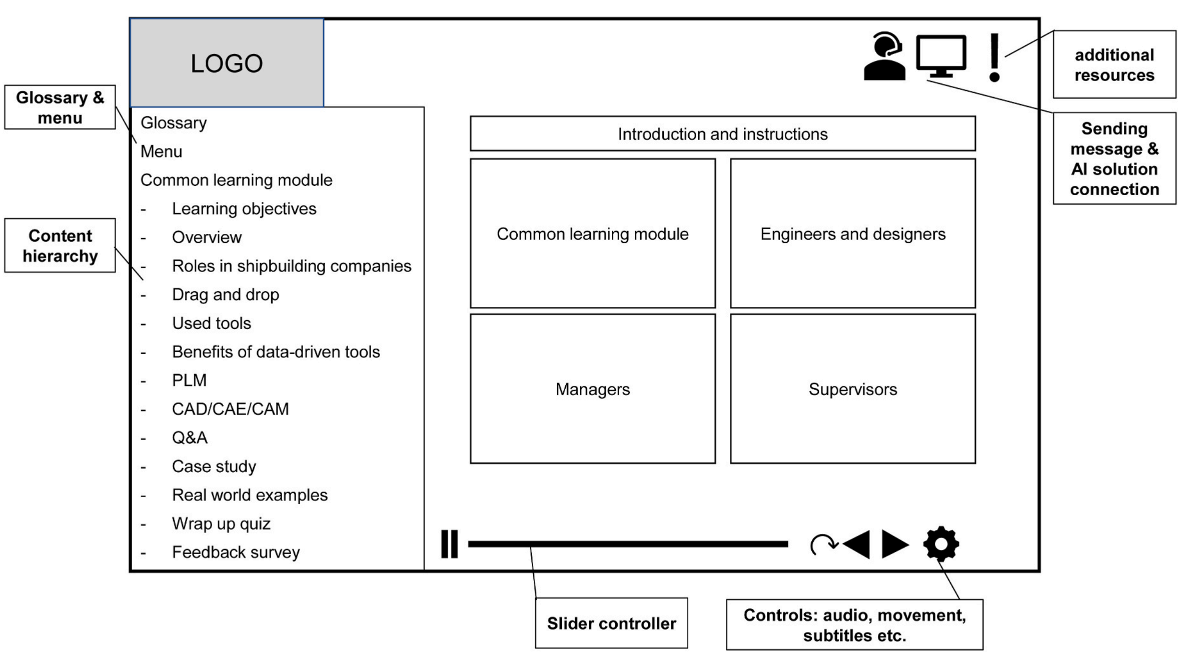

Fig. 2. Illustration of the front page and main functionalities of the learning solution.

matters in shipbuilding projects rather than how to use specific tools. By doing so, it supports attitude formation and readiness to engage with digital tools, which were identified as critical prerequisites during the needs analysis.

4.3. Role-specific modules

Following the common module, participants engage with one of three role-specific modules, each designed to align with the tasks, responsibilities, and decision-making contexts of a particular user group.

The module for engineers and designers focuses on how digitalisation supports technical work, design coordination, and lifecycle data management. Content addresses issues such as integrating digital tools into design workflows, understanding the downstream implications of design data, and supporting collaboration across engineering disciplines. Learning activities in this module prioritise visual demonstrations, drill-and-practice exercises, and examples from design and engineering contexts. This design reflects the need for engineers and designers to see how data-driven tools connect to their daily technical tasks.

The supervisors' module emphasises the role of digitalisation in operational coordination, monitoring, and team-level decision-making. Content highlights how digital tools support situational awareness, information flow between roles, and coordination across project phases. Learning activities focus on demos and scenario-based examples, interpretation of digital information for operational decisions, and understanding how digital data supports communication between teams. This reflects supervisors' position at the intersection of technical execution and managerial oversight.

The managers' module addresses digitalisation from a strategic and organisational perspective. Content focuses on understanding the value of digitalisation for project performance, decision-making, and long-term organisational development rather than on operational detail. Learning activities are designed to support high-level understanding, reflection on strategic implications, and alignment between data-driven tools and project goals. The module avoids technical depth in favour of conceptual clarity and relevance to managerial responsibilities.

5. Results

This section presents the results of the study based on data collected during the design, evaluation, and refinement of the learning solution. In line with the ADR approach, the results focus on how the learning solution performed across iterative evaluations and how it was perceived by different role groups in the final evaluation.

5.1. Learning preferences as design input

The learning preferences and expectations related to data-driven tools in shipbuilding projects were examined through a survey administered to subject-matter experts. As reported (Tacgin and Martinsuo, 2025), 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 emphasising the benefits of workshops and seminars. The third preference was eLearning with teacher support (n = 4).

The most expected outcome 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 eLearning and simulation (n = 9). Seven participants selected interactive videos and quizzes 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). The answers to open-ended questions showed that the additional tools might be useful for the learning solution. The responses highlighted the importance of practical, interactive, and personalised resources. Participants suggested incorporating visual aids and ensuring the availability of updated interactive visual resources to enhance engagement. To offer immediate guidance and practical application, it was suggested that feedback options and problem-solving demo sessions should be included.

According to the CRAMP model (Romiszowski, 2013), engineers and designers must develop and implement data-driven shipbuilding tools in order to optimise design by minimising 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 tasks requiring skilled movement, a progressive part method should be used, teaching each part sequentially. Supervisors are required to improve team performance, so both conceptual understanding (C) and attitude change (A) are necessary. 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.

5.2. Pilot evaluation of the learning solution

The pilot version of the learning solution was evaluated during a face-to-face workshop involving 17 participants working in six groups. This evaluation was to assess the UI, structure, applied andragogical approach, and terminological knowledge of the learning solution.

Participants evaluated design features as effective despite emphasising the lack of individualised content groups, as expressed by some feedback responses: *"… a target group is missing; instead of concentrating on a specific group, the course tries to cover everything, leading to nonspecific information."* (C1) *"… The intro given is too general, for example, shipbuilding is already digitalised, but we at the project are digitalising shipbuilding processes …"* (C2). The glossary of technical terms was described as valuable to support understanding across different professional roles and to reduce ambiguity related to data-driven terminology. Participants expressed positive views regarding video captions and adjustable playback speed, which were perceived as enhancing flexibility and learner control. Interactive quizzes with instant feedback were evaluated positively, with a majority of participants reporting that this feature supported learning reinforcement during the learning process.

The pilot evaluation revealed areas for improvement related to platform usability and technical performance as expressed in some feedback: "*Burger menu buttons are part-time broken and not intuitive ….*" (C3). While participants recognised the potential of the learning solution, they noted that usability issues could negatively affect the learning experience if not addressed. Some feedback related directly with usability: "*… it is good to have it interactive; however, we could have an instruction to click to not depend on video, speech control, case study videos of ship walkthrough is good …*" (C4) and *"… about the real-world examples, chance to link other resources is very cool, …., good feature playback speed and great captions, but too small …"* (C5). These observations informed subsequent revisions of both content and implementation.

5.3. Final role-based evaluation of the learning solution

Subject-matter experts reviewed the edited versions of the learning material after the pilot evaluation and provided feedback on content clarity, relevance, role alignment, and andragogical effectiveness. After seven revision cycles, feedback led to improvements in terminology, visual presentation, examples, and alignment between learning activities and role-specific work practices. Some of the comments of subject experts are presented below:

> SE1: The mouse pointer shows that there should be some links to CAD Software, but nothing is available, only the mouse icon changes from the arrow to a finger …

> SE2: The activity of clicking in X was very effective, although it did not fully show the advantages of such collaborative tools/dashboards. By doing the activity, one learns to work in X, but its potential is not that clearly shown. For example, when an open issue is created, it would be nice to show the effect for the respective team members in the project dashboard or activity stream.

The final version of the learning solution was evaluated through online role-specific sessions involving managers (N = 8), engineers and designers (N = 5), and supervisors (N = 5). Participants completed the structured evaluation instruments assessing suitability of learning objectives, terminological correctness, learning activities, feedback, UI features, and learning scenarios.

Table 3 presents the average evaluation scores of the nine criteria for each group. As seen, the learning solution received high ratings across groups, with mean scores ranging from 3,75 to 5,00.

Supervisors reported the highest evaluations for engaging materials and activities (mean = 5,00), learning objectives (mean = 4,60), terminological correctness (mean = 4,60), and concept reinforcement (mean = 4,80). Engineers and designers rated feedback on activities (mean = 4,80), engaging materials and activities (mean = 4,60), and user-friendly interface (mean = 4,60) highly, while providing slightly lower ratings for practical scenarios (mean = 4,00) and concept reinforcement (mean = 4,00).

Managers' evaluations were positive but showed lower ratings for practical scenarios (mean = 3,75) compared to the other groups. Managers rated learning objectives (mean = 4,43) and feedback on activities (mean = 4,50) highly, while evaluations of usability-related criteria showed greater variation.

Across all role groups, visual design, readability and terminological correctness received high scores, indicating that the learning solution supported accessibility and shared understanding across heterogeneous professional roles.

6. Discussion

In contrast to prior studies summarised in Table 1, which primarily examined digital tools, awareness and role-relevant knowledge outcomes, or learning methods in isolation, this study integrates these perspectives by examining how a role-sensitive learning solution can be designed and evaluated in a real project-based firm context. Methodologically, the study illustrates a way in which ADR can be used to develop workplace learning solutions through iterative collaboration with expert participants in complex project-based settings. By adopting an ADR approach (Sein et al., 2011), this study contributes to understanding not only what kinds of digitalisation awareness and role-relevant knowledge are needed in PBFs, but also how learning solutions can be structured to address differences between professional roles. Accordingly, the study evaluated the design, perceived usefulness, and role relevance of the learning solution and yielded related design principles, rather than directly measuring competence acquisition among participants.

Table 3
Average scores of material evaluation by the participants. (scale 1 … 5).

Items	Engineers (n = 5)	Managers (n = 8)	Supervisors (n = 5)	Mean (N = 18)
Learning objectives	4,20	4,43	4,60	4,41
Terminological correctness	4,20	4,29	4,60	4,35
Engaging materials and activities	4,60	4,25	5,00	4,56
Feedback on activities	4,80	4,50	4,60	4,61
Concept reinforcement	4,00	4,00	4,80	4,22
User-friendly interface	4,60	4,13	4,40	4,33
Accessible components (UI)	4,60	4,13	4,40	4,33
Practical scenarios	4,00	3,75	4,20	3,94
Visual design and readability	4,40	4,38	4,20	4,33

Design principle 1. Acknowledge role-relevant learning needs. This study acknowledged that understanding the expectations of diverse professionals in PBFs is crucial to designing and developing effective learning solutions to meet the expectations of learners to reach desired learning outcomes. The results demonstrate that although engineers/designers, supervisors, and managers share a common need for clarity and relevance in digitalisation learning, they differ in how they evaluate specific andragogical and design features. Supervisors' high ratings across criteria suggest alignment between the learning solution and their intermediary role in project execution, which requires both conceptual understanding and practical coordination capabilities. Engineers and designers placed value on feedback mechanisms, visual materials, and interface usability, reflecting their workflow-oriented interaction with digital tools. Despite being positive, managers evaluated practical scenarios cautiously, consistent with their strategic and oversight-oriented perspective. These findings align with earlier research suggesting that digital tools in PBFs affect roles differently due to variations in decision-making responsibilities and proximity to operational work (Toukola and Ahola, 2022; Whyte et al., 2016) and offer domain-specific evidence in PBFs involved specifically in complex projects in shipbuilding.

Design principle 2. Translate learning needs to role-relevant learning modules that together form a coherent learning structure. In light of research analysed in Table 1, prior studies had not translated the differences of learning needs to learning solutions differentiated according to learners' heterogenous needs. This study adds to existing literature (Marnewick and Marnewick, 2022; Ninan et al., 2022; Papadonikolaki et al., 2022) by empirically demonstrating that role-sensitive modular learning can support both shared understanding and differentiated awareness and role-relevant knowledge. This is why the learning solutions for the diverse learners should be designed based on a modular structure; therefore, revision and update regarding the instant requirements will be viable.

Design principle 3. Enable a blended learning approach, also in a digital learning solution. This study suggests that a blended learning approach, combining instructional sections, cases, examples, quizzes, and other learning formats in a common module with role-specific modules, is a feasible approach to address heterogeneous learning needs in PBFs. Considering the idea of(Valverde-Berrocoso and Fernández-Sánchez, 2020) , the principles of universal design for learning were utilised to craft the learning solution that enhances learning outcomes across diverse groups, particularly in blended learning settings. The common learning module supported the development of generic terminology and conceptual alignment for users. This finding is relevant in contexts where digital tools such as ERP, PLM, or BIM systems span the entire project lifecycle and require coordination across organisational boundaries (Papadonikolaki et al., 2022; Whyte et al., 2016).

Design principle 4. Allow practitioners to contribute, when refining the learning solution. The developed learning solution was able to meet the participants' expectations concerning practical relevance and decision-making, thanks to the role-specific modules (Marnewick and Marnewick, 2022) and iterative refinement across evaluation cycles. This balance was achieved through iterative subject-matter expert evaluations (Jääskä et al., 2022). The findings suggest that learning solutions for data-driven tools in PBFs in the shipbuilding industry should be viewed as evolving artifacts that benefit from ongoing feedback and revision rather than as static training products.

This study advances design knowledge rather than predictive theory from a design science perspective (Gregor and Hevner, 2013). The results suggest that role-sensitive learning needs and their translation into a modular structure, blending learning mechanisms, and iterative expert involvement in refining the learning solution are useful design principles to develop effective learning solutions (Sein et al., 2011; Mullarkey and Hevner, 2019; Romme and Holmström, 2023) for PBFs and enhance the digital awareness and role-relevant knowledge of personnel regarding data-driven systems. This research integrates evaluation into the design process, allowing for iterative refinement of the artifact, in contrast to many studies that assess merely the learning outcomes. In situations where large-scale learner samples are unsuitable or impractical, this study also highlights the importance of expert-based evaluation. Subject-matter experts can offer rich, contextually grounded insights that support the development of transferable design principles in complex industrial settings like shipbuilding.

7. Conclusions

This study set out to examine how a learning solution can be designed to address role-based differences in digitalisation awareness and role-relevant knowledge needs in PBFs. Drawing on an ADR approach and empirical evidence from the research project, this study developed and evaluated a modular learning solution that integrates a shared conceptual foundation with role-specific learning modules.

The findings reveal that while digitalisation creates common challenges across professional roles, engineers/designers, supervisors, and managers differ in how they engage with and evaluate learning content related to digitalisation. The results demonstrate that a role-sensitive learning design can simultaneously support shared understanding, differentiated awareness, and role-relevant knowledge development. Especially, the combination of common learning and role-specific modules enabled participants to relate digitalisation concepts to their work contexts while maintaining cross-role alignment.

From a theoretical perspective, this study contributes to research on PBFs by extending existing knowledge on digital tools and awareness and role-relevant knowledge into the domain of learning design. Rather than treating digitalisation awareness and role-relevant knowledge as uniform or tool-specific, this research highlights the importance of designing learning solutions that explicitly account for role heterogeneity within project organisations. This study also contributes to ADR by illustrating how iterative, expert-driven evaluation can be used to refine learning artifacts in complex industrial settings.

From a practical perspective, the findings suggest that project-based organisations seeking to promote digitalisation should invest not only in digital tools but also in role-sensitive learning solutions that support adoption, collaboration, and awareness and role-relevant knowledge development. Uniform training approaches risk overlooking differences in responsibilities, decision-making logic, and learning expectations across roles. Modular, flexible learning designs can help organisations address these challenges effectively.

While the study was conducted in the shipbuilding sector, the design principles identified are likely to be relevant to other project-based industries characterised by complex products, long lifecycles, and cross-role interdependencies. Future research could build on this work by examining the long-term effects of role-sensitive learning on digital tool adoption and project performance, as well as by testing similar learning designs in other industrial contexts.

For practitioners, the findings suggest that attempts to promote digitalisation awareness and role-relevant knowledge through uniform learning materials may be insufficient in PBFs. Instead, learning solutions should explicitly recognise role-based differences in how digitalisation is understood, valued, and enacted in daily work. Organisations developing or adopting digital tools should invest not only in implementation but also in role-sensitive learning design to support adoption, collaboration, and long-term awareness and role-relevant knowledge development.

The results indicate that features such as glossaries, visual explanations, external resources, case studies and flexible learner control can facilitate understanding. Besides, role-specific scenarios and activities enhance perceived significance. These insights are relevant for organisations operating in multi-project environments where coordination across roles and disciplines is critical.

This study has some limitations that open avenues for future research. First, the focus on PBFs and digitalisation in the shipbuilding sector delimits the research to project delivery of unique and complex systems where digitalisation is approached somewhat differently than in higher-volume manufacturing or research and development. Thereby also, the developed learning solution remained on a fairly general level of digitalisation awareness and knowledge, instead of going to details of specific tools, which limits the validity to rather generic learning designs. We are aware of the necessity for developing digitalisation competences also at the level of separate digital tools, which was now excluded, but role-specific investigation of such tools might be relevant for future research. Second the evaluation of the developed learning solution relied on expert participants within a specific research consortium rather than a large population of end users, which limits the generalisability of the findings. The limited number of expert responses offer exploratory evidence, they covered the research consortium's network sufficiently well, and they were used in this study in a design-informing manner, whereas statistical generalisation was not pursued. Future studies could examine how similar learning solutions or this learning solution on the chosen learning platform perform when deployed at scale in a broader sample of PBFs. Third, the study focused on perceived usefulness and design quality rather than longitudinal learning outcomes or behavioural change. Future research could investigate how role-sensitive learning affects the adoption of digital tools over time.

In addition, while the study was conducted in the shipbuilding sector, the underlying design principles may be applicable to other project-based industries such as construction, engineering, or infrastructure development. Comparative studies across sectors would help to validate and refine these principles.

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CRediT authorship contribution statement

Zeynep Tacgin: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Validation, Visualization, Writing – original draft. **Miia Martinsuo:** Conceptualization, Project administration, Resources, Supervision, Validation, Writing – original draft.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Data availability

The data that has been used is confidential.

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