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Research article

A systematic literature review on knowledge transfer in safety-critical systems: focus on tacit knowledge

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A B S T R A C T

The departure of experienced individuals from an organization can lead to a substantial decline in productivity, efficiency, and safety, primarily due to the loss of specialized knowledge and skills. The intuitive understanding gained through long-term engagement in operational safety, procedural compliance, and the handling of non-normal situations is often tacit in nature—unspoken, experience-based, and difficult to formalize or document. Effectively transferring this type of tacit knowledge requires the application of targeted strategies. This systematic literature review, conducted in accordance with the PRISMA guidelines, aims to identify and synthesize existing methodologies for knowledge transfer, with a particular emphasis on tacit knowledge in safety-critical systems. A total of 22 empirical and non-empirical studies from sectors such as nuclear power, offshore operations, aerospace, control rooms, maritime, and railways were systematically reviewed. The findings were analysed, categorized, and presented using the SECI model. The review underscores the critical role of knowledge management and the need for effective methods to support knowledge transfer. It also highlights the importance of personal interactions grounded in mutual trust within social communities—such as apprenticeships—in facilitating the transfer of tacit knowledge. However, these methodologies are often inconsistently documented. Informal interactions likewise contribute significantly to tacit knowledge transfer. In safety-critical system environments, however, informal organizational structures can pose risks, as such channels may become untraceable and lead to deviations from established standard operating procedures (SOPs). Additionally, the review reveals inconsistencies in how tacit knowledge is defined and operationalized, which complicates the development of research instruments. In summary, this systematic literature review offers a comprehensive overview of existing research on tacit knowledge transfer in safety-critical systems, emphasizing common practices and identifying key gaps in documentation and methodological consistency.

1. Introduction

1.1. Knowledge management

Effective knowledge management (KM) is crucial for organizations to improve performance [1], maintain competitiveness [2], drive productivity and innovation [3], and ensure the continued success of safety-critical operations [4]. However, organizations are at significant risk of knowledge loss when experienced employees depart [5]. KM involves the systematic processes of creating, sharing, utilizing, and managing knowledge within an organization.

Effective KM systems incorporate strategies designed to identify, capture, store, and transfer data, information, and knowledge [1, 6]. Formal training programs, such as classroom instruction, computer-based training, and course materials, serve as key KM strategies for disseminating knowledge and developing skills. In contrast, informal approaches—such as social networking, peer assistance, and casual interactions (e.g., coffee-break discussions) [7]—play a complementary role in knowledge transfer. Mentoring and coaching offer opportunities for experienced individuals to guide less experienced colleagues, facilitating knowledge transfer through observation and hands-on practice [5]. The successful implementation of KM requires alignment with organizational objectives, active

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employee engagement, and the development of suitable technological infrastructure to support knowledge sharing and storage [8].

Implementing effective KM also involves several challenges, including resistance to change, as employees may, for example, be reluctant to share knowledge due to concerns about job security or perceived loss of ownership [9]. Additionally, the complexity of capturing non-codified knowledge, such as tacit knowledge, is often underestimated [1]. Technological limitations, including inadequate or incompatible systems, can also hinder knowledge sharing [9]. Moreover, a lack of alignment between KM strategies and organizational culture can significantly reduce the effectiveness of KM initiatives [6].

1.2. Knowledge

From a cognitive perspective, knowledge can be defined as information that has been processed and internalized by an individual [10]. The relationship between data, information, knowledge, and wisdom—commonly referred to as the DIKW hierarchy—represents a continuum of understanding [11,12]. At its core, data consists of raw facts that lack meaningful context when considered in isolation [12]. Once processed, data is transformed into information, acquiring context and meaning [13]. Through further refinement and integration with personal experience, information evolves into knowledge. At the apex of the hierarchy, wisdom enables sound judgment and decision-making, often incorporating ethical considerations and long-term perspectives [14].

Various frameworks differentiate between explicit, implicit, and tacit knowledge. Explicit knowledge is easily articulated and can be shared through various mediums, such as literature, instructions, and manuals [1]. Implicit knowledge includes ideas, strategies, rules of thumb, or processes that remain undocumented but can potentially be expressed [13,15]. In contrast, tacit knowledge refers to knowledge that is difficult or impossible to articulate, often acquired through extensive experience, and is crucial for performing complex tasks [16]. Distinguishing between these types of knowledge helps avoid oversimplification and provides a clearer understanding of their roles within organizational contexts [6,17]. Despite their distinctions, explicit, implicit, and tacit knowledge often overlap, making them challenging to separate [18].

1.3. Tacit knowledge

Tacit knowledge plays a central role in KM, and its effective management is crucial for several reasons. First, because it is deeply embedded in individual experience, tacit knowledge is fundamental to the development of expertise and skills [19]. This type of knowledge is personal, context-specific, and inherently difficult to codify, formalize, articulate, or communicate [16,20]. Tacit knowledge evolves over time through practice and interaction, often in social contexts [1]. It can manifest as practical skills [11], know-how [21], or muscle memory [22]. Additionally, it encompasses the intuitive, experience-based understanding that individuals apply across various tasks and activities [16].

Although tacit knowledge is difficult to articulate, it can be transferred through social interactions. However, such interactions do not always lead to meaningful or effective learning outcomes [23]. What may be tacit for one individual can, in some cases, be explicit for another [24,25]. Ambrosini and Bowman [26] and Spender [27] argue that tacit knowledge is inherently underspecified and resists formal operationalization. As a result, research on tacit knowledge often requires a mixed-methods approach to effectively address its complexity. Moreover, tacit knowledge manifests in various forms and remains inconsistently defined in the literature [26].

Tacit knowledge is a crucial yet often ambiguous and misunderstood aspect of human cognition, learning, and expertise. This ambiguity stems from its varied interpretations, synonyms, and definitions. The primary challenges in researching tacit knowledge relate to issues surrounding its definition and operationalization. First, tacit knowledge encompasses multiple domains, including scholarly, operational, didactical, and cultural contexts [28]. Distinguishing tacit knowledge from closely related concepts—such as pattern recognition, intuition, skill, and procedural knowledge—presents significant challenges due to their interrelated and overlapping nature in practice. These distinctions are crucial for understanding cognitive processes, learning mechanisms, and the development of expertise [21]. Additionally, research instruments designed to study tacit knowledge may require individuals to articulate aspects of their knowledge that are inherently difficult or even impossible to fully express [16]. As a result, this resistance to articulation poses challenges for the operationalization of tacit knowledge. To address these challenges, a variety of research methodologies are employed, with ethnography, case studies, interviews, and observations being particularly prominent, often used together to achieve triangulation.

1.4. Knowledge transfer

Knowledge transfer is a process that involves the sharing, dissemination, integration, and application of knowledge. It plays a pivotal role in enhancing both individual and organizational performance [29], fostering innovation [3,27], and enabling organizations to learn from past experiences. By helping to identify and prevent recurring mistakes, knowledge transfer promotes the adoption of best practices that improve operational effectiveness [6]. Additionally, it facilitates skill development, enhances decision-making, and increases efficiency within teams [29]. Furthermore, knowledge transfer ensures continuity, particularly in contexts where expertise is critical [1,29], such as in safety-critical systems (SCS). In these environments, seamless knowledge transfer supports risk management, system reliability, and the development of effective responses to unforeseen challenges.

The SECI (Socialization, Externalization, Combination, Internalization) model [1] is a framework for understanding knowledge transfer processes within organizations, with a particular focus on the interaction between tacit and explicit knowledge. Compared to other models, such as the Knowledge Management Cycle model [30], which encompasses the full range of KM activities, the SECI model is especially effective in capturing the nuanced aspects of knowledge processes, including the transfer and transformation of

tacit knowledge. Similarly, while models like the Social Capital model [16] emphasize the importance of relationships, networks, and trust in facilitating tacit knowledge transfer, they lack clear mechanisms for managing or formalizing these processes and offer limited means for measuring the impact of social capital on knowledge transfer. In contrast, the SECI model provides a more structured approach to understanding the dynamic interplay between tacit and explicit knowledge.

The SECI model conceptualizes knowledge creation as a continuous process involving four modes: (S) Socialization (tacit-to-tacit), where knowledge is transferred in a non-codified form through social interactions, such as apprenticeships; (E) Externalization (tacit-to-explicit), where tacit knowledge is articulated or represented explicitly, often through dialog; (C) Combination (explicit-to-explicit), where explicit knowledge is integrated and organized, such as through guidelines or documentation; and (I) Internalization (explicit-to-tacit), where explicit knowledge is absorbed and transformed into tacit knowledge through practice and skill acquisition. While the SECI model emphasizes the importance of social interactions and experiential learning in tacit knowledge transfer, it has been critiqued for its high level of abstraction, lack of empirical grounding, and limited guidance on managing complex, real-world scenarios [31,32]. Despite these limitations, the model remains valuable due to its flexibility and applicability across diverse organizational contexts.

1.5. Safety-critical systems

Systems incorporating automation, digitalization, and computerized interfaces [33] have been implemented across various industry sectors to achieve safe, economical, and environmentally sustainable operations [34]. These systems share inherent complexity and the potential for severe consequences in the event of malfunction or failure [35]. If a malfunction or failure results in unacceptable outcomes, such as loss of life, significant property damage, or environmental harm [33,36], the system is classified as a SCS [36]. However, SCS are specifically designed to be reliable and to mitigate such consequences [37]. Examples of SCS include aerospace, medical, and telecommunications systems [4,34], as well as maritime and offshore systems [38,39], nuclear power production (NPP) [40,41], and the process industry [42]. An increasing number of common information systems are also becoming safety-critical, as they can have secondary effects on activities within or adjacent to SCS [38,39]. In a broader sense, they may be classified as safety-critical if their malfunction or failure could result in monetary loss or loss of life [36]. An SCS requires high reliability, safety, and performance [37]. For example, safety-critical aircraft systems are designed so that catastrophic failure conditions are extremely improbable—on the order of 1×10^{-9} or less per flight hour [43,44].

1.6. Tacit knowledge transfer in safety-critical systems

The specific characteristics of SCS, such as the severe consequences of failure or malfunction, influence KM [4] and, consequently, have indirect safety implications. Explicit knowledge among experienced operators is typically documented in formalized procedures, such as instructions [40] or manuals [45–47]. However, tacit knowledge, accumulated over time by experts, is also a crucial source of expertise. The identification, documentation, articulation, repository management, and communication of tacit knowledge are essential for transferring this knowledge from experts to novices [38,39]. Methods for transferring tacit knowledge in an SCS include scenario analysis [21,26], focus groups [48], mentorship [22,40,47], informal dialogues during coffee breaks [21,45,48], job rotation [21], and continuous, localized recruitment [41]. Members working in an SCS often operate in shift teams [40], which can be likened to families where knowledge is exchanged and reproduced [4], as defined by Nonaka and Takeuchi [1] in terms of socialization. However, this process of knowledge transfer, which may take several years, is rarely documented [38,39]. Additionally, in SCS environments, informal organizational structures present challenges, as informal channels can become undetectable, leading to the use of non-standard procedures instead of established Standard Operating Procedures (SOP), thereby increasing the risk. Tacit knowledge, knowledge transfer methods, and SCS have been discussed extensively in the literature. However, a systematic compilation of tacit knowledge transfer specifically within SCS could offer valuable insights into this important topic.

1.7. Purpose

The purpose of this exploratory systematic literature review is to summarize and provide an overview of research on methods for transferring knowledge in SCS, with a focus on tacit knowledge transfer.

Table 1
Definitions of SCS domains used in the systematic literature review.

Domain	Definition
Aerospace	Activities involving the operation, training, and education related to aircraft and spacecraft [49]
Maritime	Activities involving the operation, training, and education related to ships and marine vessels [50]
Offshore	Activities involving the operation, training, and education related to offshore structures and installations, including oil and gas facilities and offshore renewable-energy systems [51].
NPP	Activities involving the operation, training, and education related to nuclear power plants and energy generation [52]
Railway	Activities involving the operation, training, and education related to trains and railway systems [53]
Control room	Activities involving the operation, training, and education related to control room systems and monitoring environments [54]

2. Methods

2.1. Scope of the review

This literature review includes SCS from the following domains: aerospace, maritime, offshore, NPP, railway, and control rooms (Table 1). The focus is specifically on *tactical* operators within these domains, rather than on design or organizational aspects. Although air traffic control (ATC) and train control (TC) are control room functions that are not inherently tactical in conducting transport operations, they are closely related to such functions.

2.2. Research process

The methodology for the systematic literature review was based on the framework established by Polit and Beck [55] and was conducted in accordance with the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines [56]. However, the PRISMA guidelines were adapted to meet the specific requirements of this review. The review was conducted in eight steps. Step 1: Defining the study purpose and research questions. Step 2: Developing a search strategy based on the SPIDER methodology (Sample, Phenomenon of Interest, Design, Evaluation, Research type) [57] and establishing inclusion criteria following the EPPI Centre (Evidence for Policy & Practice Information Centre) guidelines [58]. Step 3: Conducting the literature search, including an initial search, test search, main search, and update search. Step 4: Screening and selecting studies in accordance with PRISMA guidelines. Step 5: Extracting and compiling information, followed by a critical appraisal using appropriate tools: CASP (Critical Appraisal Skills Programme) [59] for qualitative studies, MMAT (Mixed Methods Appraisal Tool) [60] for mixed-methods studies, and AACODS (Accuracy, Authority, Coverage, Objectivity, Date, Significance) [61] for non-empirical sources (grey literature). Step 6: Assessing, integrating, and compiling findings according to the SECI model [1]. Step 7: Extracting the Socialization and Externalization dimensions of the SECI model to evaluate tacit knowledge transfer. Step 8: Presenting the results.

2.2.1. STEP 1: Study purpose and research questions

The purpose of the study was to develop an understanding of methods for knowledge transfer in general, and tacit knowledge transfer in particular, within SCS. The phenomenon of interest was therefore defined as methods for transferring tacit knowledge in SCS. Based on this, the following research questions were formulated.

- RQ1: Which methods for transferring knowledge in safety-critical systems are described in the literature?
- RQ2: Which methods for transferring tacit knowledge in safety-critical systems are described in the literature?
- RQ3: How are the methods identified in RQ1 and RQ2 supported methodologically?

2.2.2. STEP 2: Search strategy

The SPIDER methodology was employed to support the literature review by guiding the design of search strategies, including the selection of search terms [57,62]. Based on the SPIDER framework (Table 2), an initial set of search terms was developed and assessed through preliminary appraisal. These terms were used to construct the initial Test Search string: (safety-critical system) AND (operator) AND (tacit knowledge) AND (knowledge transfer) AND (method*). The search string was subsequently evaluated and iteratively refined during the literature search process described in STEP 3 and Table 3.

The inclusion criteria, based on EPPI-Centre recommendations [58], encompassed literature that addressed RQ1–RQ3, including both empirical and non-empirical (grey) literature published between 1993 and 2023. Eligible studies employed qualitative, quantitative, or mixed-methods approaches and focused on knowledge transfer, tacit knowledge, or tacit knowledge transfer. The literature search methodology was refined in collaboration with an information specialist at a university library to ensure methodological rigor [63]. EndNote (Version X9.3.3) was used for reference management, with Microsoft Excel (Version 2024) as a backup tool.

Table 2
Description of the systematic literature review based on SPIDER[a] methodology.

Element	Definition	Search words
Sample	Expert and novice operators interacting during normal work duties and/or training in safety-critical systems	(safety-critical system*) AND (operator*)
Phenomenon of Interest	Novice operators acquiring knowledge in terms of informal knowledge transfer	(tacit knowledge) AND (knowledge transfer)
Design	Peer-reviewed scientific literature as well as grey literature	Not applicable[b]
Evaluation	Explorative, explanatory, descriptive, using observations, interviews, questionnaires, document analysis, surveys	(method*)
Research type	Qualitative, quantitative, and mixed-methods studies	Not applicable[b]

[a] Sample, Phenomenon of Interest, Design, Evaluation, and Research type.
[b] The SPIDER methodology was used in the formulation of the search words but was not used to generate search terms since the "Design" (D) or the "Research type" (R) resulted in an unreliable search strategy.

Table 3
Search strings evaluated and used during the literature search process.

Search string
INITIAL SEARCH
tacit knowledge[a], tacit knowledge and safety-critical systems[a], (tacit knowledge AND safety-critical systems)
TEST SEARCH
(safety-critical system*) AND (operator*) AND (tacit knowledge) AND (knowledge transfer) AND (method*)
First adjustment of the Test Search
(tacit knowledge) AND (knowledge transfer)
Second adjustment of the Test Search
(tacit knowledge) AND (knowledge transfer)
(implicit knowledge) AND (knowledge transfer OR knowledge management OR knowledge sharing)
(procedural knowledge) AND (knowledge transfer OR knowledge management OR knowledge sharing)
(skills) AND (knowledge transfer OR knowledge management OR knowledge sharing)
(know-how) AND (knowledge transfer OR knowledge management OR knowledge sharing)
(muscle memory) AND (knowledge transfer OR knowledge management OR knowledge sharing)
(intuition) AND (knowledge transfer OR knowledge management OR knowledge sharing)
(reflexes) AND (knowledge transfer OR knowledge management OR knowledge sharing)
(instincts) AND (knowledge transfer OR knowledge management OR knowledge sharing)
(cultural norms) AND (knowledge transfer OR knowledge management OR knowledge sharing)
(pattern recognition) AND (knowledge transfer OR knowledge management OR knowledge sharing)
(social learning) AND (knowledge transfer OR knowledge management OR knowledge sharing)
(apprenticeship) AND (knowledge transfer OR knowledge management OR knowledge sharing)
MAIN SEARCH
(tacit knowledge) AND (knowledge transfer)
UPDATE SEARCH
(tacit knowledge) AND (knowledge transfer)

[a] Plain text used.

2.2.3. STEP 3: Literature search

The literature search was conducted in four stages: (1) an Initial Search, (2) a Test Search, (3) a Main Search, and (4) an Update Search. An information specialist was consulted both during the initial development of the search strategy and during the subsequent literature search process. Search strings were iteratively refined throughout the process (Table 3).

An *Initial Search* was conducted on 30 November 2023 using a university library's all-database search tool, as well as Google Scholar (unrestricted search). The purpose of this search was to identify any previously published literature reviews on the topic and to map the research field in terms of relevant keywords, terminology, potentially overlapping subjects, and key literature. A manual search was also carried out, including a review of references and terms in subject-specific journals [5,16,64,65] and thesauruses [66,67]. Additionally, consultations were continuously held with an information specialist, a subject matter expert, and faculty peers. No previously published systematic literature reviews on the topic were identified.

A *Test Search* was conducted on 15 December 2023 using Web of Science and Google Scholar. The purpose of the Test Search was to calibrate the search strategy against the database content by evaluating indexation, candidate keywords, search terms, titles, filters, and abstracts in relation to a predefined Gold set of key literature [5,16,38,42,68–71]. The initial Test Search string was found to be overly restrictive, as it failed to retrieve all records in the Gold set. The search strategy was therefore iteratively adjusted, as shown in Table 3. A less restrictive search string successfully retrieved all Gold set records while producing a manageable number of results. Alternative search strings incorporating related concepts and terminology identified during the Initial Search were also evaluated; however, these either reduced or did not improve retrieval of the Gold set. Based on this evaluation, the broader search string "(tacit knowledge) AND (knowledge transfer)" was selected for the Main Search.

The *Main Search* was conducted on 1 January 2024 using the final search string "(tacit knowledge) AND (knowledge transfer)" (Table 3). To reduce the risk of missing relevant literature, multiple data sources were utilized [28,48,72,73], including Web of Science, PsycInfo, Scopus, IEEE Xplore, ERIC, and Google Scholar. These databases were selected, in consultation with an information specialist at the university library, to ensure coverage of diverse interdisciplinary and cross-cutting domains—namely, behavioural sciences, technical fields, and human–machine interaction. In parallel, a backward chain search [71,74,75] was conducted to trace the origins and development of the topic. This process also facilitated the identification of key subject matter experts [76] and relevant organizations [77].

An *Update Search* was conducted on 1 May 2024 to mitigate the risk of eligible studies being published unnoticed between the original cutoff point and the final stages of publication. Higgins et al. [78] recommend a minimum interval of six months for conducting an update search. This process was not limited to the search execution alone but also revisited the study's purpose, research

questions, selection criteria, and search strategies [78]. The update search did not yield any additional findings.

2.2.4. STEP 4: Screening and selection

The main search (Fig. 1) returned a total of 4732 records from the selected *databases*. Following the removal of 1361 duplicates and 2993 ineligible records not meeting the inclusion criteria, 378 records remained. These records were entered into an Excel spreadsheet, which included fields for ID number, year of publication, author(s), title, abstract, source, domain, eligibility appraisal (including reasons), and additional comments. Titles and abstracts were randomly assigned for review: the primary author screened 100% of the records, while the secondary author reviewed a randomly selected 25% to help mitigate bias and ensure redundancy. Each record was appraised using a three-point scale: 1 = include, 2 = re-appraise, and 3 = exclude. Following this initial appraisal, 324 records were excluded due to incorrect domain alignment, and an additional 19 records were excluded for being in the correct domain but off-topic. This left 35 records, which were retrieved for full-text review. During the full-text review, 22 records were excluded: 9 for not addressing tacit knowledge transfer and 13 for not being related to SCS. The remaining 13 records met all criteria and were included in the study.

A parallel main search returned 112 records from *non-database* sources. After the removal of 9 duplicate records and 67 ineligible records that did not meet the inclusion criteria, 36 records remained. These were added to the same Excel spreadsheet used for the database-sourced records. Following an initial appraisal, 11 records were excluded due to incorrect domain alignment, and 5 additional records were excluded for being in the correct domain but off-topic. This left 20 records for full-text review. After the full-text review, 11 records were excluded: 4 did not address tacit knowledge transfer, 4 were not related to SCS, and 3 were deemed below the required research standard. The remaining 9 records met all criteria and were included in the study. Overall, the main search resulted in 22 studies being included in the review.

2.2.5. STEP 5: Extraction, compiling information, and critical appraisal

All 22 records were reviewed in full, assessed, and entered into an internal data-extraction spreadsheet containing the ID number, reference, type, domain, aims and objectives, methods, and quality appraisal. Critical appraisal (Fig. 2) was conducted using the CASP checklist for nine qualitative studies, the MMAT for one mixed-methods study, and the AACODS checklist for twelve non-empirical (grey literature) records. To mitigate potential bias, the critical appraisal of records affiliated with the authors was conducted externally.

2.2.6. STEP 6: Assessment, integration, and compilation of findings

First, all findings on tacit knowledge transfer from STEP 5 were reviewed iteratively to ensure familiarization and eliminate duplicates. Second, the findings were compared iteratively to identify units of information with similar or related content and meaning. Third, these units were grouped according to similarities in content and meaning; however, they were not synthesized or subjected to thematic analysis. Fourth, all findings were analysed, organized, and compiled in alignment with the SECI model [1], providing a

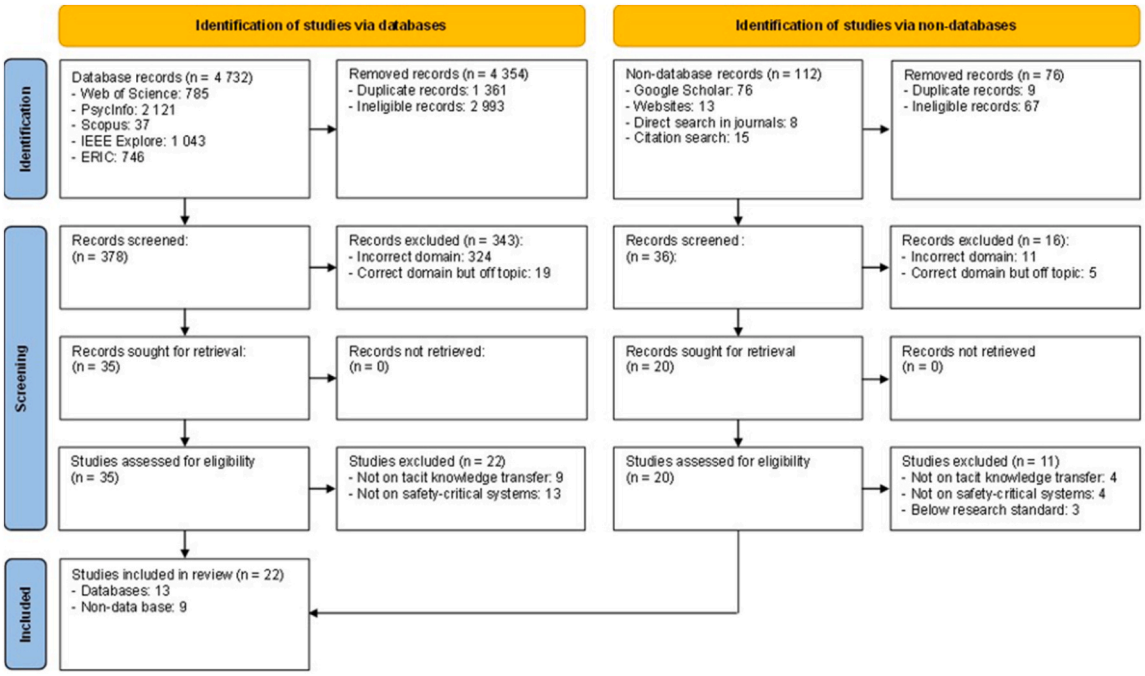

Fig. 1. Compilation of the screening and selection procedure based on PRISMA methodology [56].

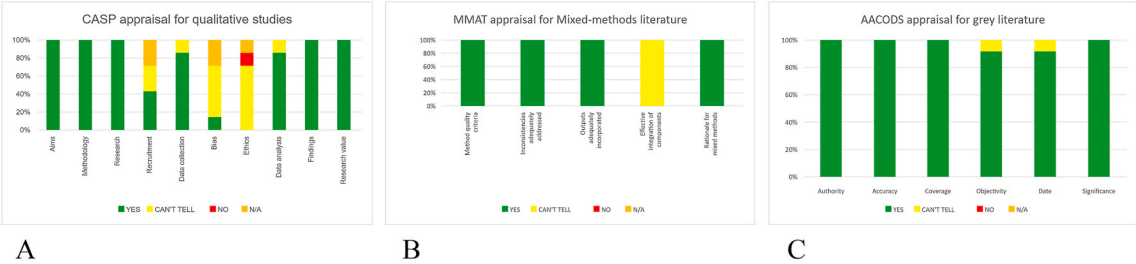

Fig. 2. Compilation of (A) CASP [59], (B) MMAT [60], and (C) AACODS [61] quality appraisals.

comprehensive overview of knowledge transfer in SCS (Appendix A, Tables 6–9).

2.2.7. STEP 7: Extraction and evaluation of Socialization and Externalization dimensions

To address the study's objectives and research questions, the socialization (tacit-to-tacit knowledge transfer) and externalization (tacit-to-explicit knowledge transfer) dimensions of the SECI model were extracted and examined in greater depth, with a specific focus on tacit knowledge transfer in SCS (Appendix A, Tables 6–7).

2.2.8. STEP 8: Presenting results

The findings on *knowledge transfer* in SCS are presented in Section 3.3, structured according to the SECI model [1] dimensions as follows: (1) Socialization (Appendix A, Table 6), (2) Externalization (Appendix A, Table 7), (3) Combination (Appendix A, Table 8), and (4) Internalization (Appendix A, Table 9). Given the complexity of the multi-layered themes, some findings exhibit overlap across categories. The findings on *tacit knowledge transfer* in SCS are presented in Section 3.4, focusing on the SECI model dimensions of (1) Socialization (Appendix A, Table 6) and (2) Externalization (Appendix A, Table 7).

3. Results

A total of 22 studies (Tables 4 and 5) were included in the systematic literature review. Additionally, a critical appraisal was performed (Fig. 2).

3.1. Heterogeneity, publication bias, and research validity

Given the qualitative and conceptual nature of the included studies, statistical assessments of heterogeneity and publication bias (e.g., I^2, Egger's test) were not applicable. Instead, heterogeneity was addressed by organizing differing perspectives on knowledge transfer and tacit knowledge transfer across SCS domains using the SECI model. Potential publication bias was mitigated through a comprehensive search strategy that included grey literature and forward and backward citation tracking. Furthermore, to address the risk of reduced construct and selection validity, this systematic literature review explicitly considers how tacit knowledge is conceptualized in each study and critically reflects on the implications of definitional diversity for the synthesis and interpretation of results.

3.2. Organisation of the results

The findings on *knowledge transfer* in SCS are organized according to all the dimensions of the SECI model [1]: Socialization, Externalization, Combination, and Internalization (see Fig. 3). Specifically, the findings related to *tacit knowledge transfer* within SCS are organized according to the Socialization and Externalization dimensions of the model.

Table 4
Compilation of findings from the literature search in terms of Domain, No, Type and No, and Region.

Domain	No	Type and No	Region
NPP	7	Doctoral thesis (1), Conference paper (2), Report (4)	Global
Offshore	4	Journal article (4)	Global
Aerospace	4	Journal article (2), Doctoral thesis (1), Conference paper (1)	Global
Control Room[a]	2	Journal article (1), Conference paper (1)	Australia, Sweden
Maritime	3	Journal article (1), Conference paper (2)	Sweden, United Kingdom
Railway	2	Journal article (2)	Australia
Total	22		

[a] Control room includes process industry, air traffic control, power generation and distribution, and rail control.

Table 5
Compilation of records from the literature search.

No	Reference	Publication Year	Type	Domain	Aims and Objectives	Methods	Quality Appraisal
1	[79]	2004	Report	NPP	To assess generation shift issues; to assess practices for attracting appropriate staff; to assess knowledge retention; to assess the transfer of knowledge to the next generation	Qualitative, explorative, descriptive, questionnaires	AACODS 6/6
2	[33]	2005	Journal article Peer-reviewed journal	Control Room	To assess operators' views on control interfaces and determine whether a control room possesses specific characteristics that render formal methods of knowledge transfer inadequate	Mixed-methods, 90 questionnaires, 8 sites, control room operators, ATC, power generation and distribution, processing, and rail control, descriptive and inferential statistics	MMAT 4/5 Unclear if different components of the study are effectively integrated to answer the research question
3	[22]	2006	Report	NPP	To develop strategic approaches and action plans to address the loss of knowledge and skills; to provide processes and tools for risk assessments on knowledge loss caused by the loss of experienced workers; to improve skills and competences of new and existing workers based on these findings	Qualitative, descriptive, review	AACODS 6/6
4	[40]	2007	Report	NPP	To survey methods for transferring competence during generation shift and for evaluation in NPP	Mixed-methods, literature review, 33 semi-structured interviews, 44 questionnaires, and observations at three NPPs, grounded theory	AACODS 6/6
5	[23]	2010	Conference paper	NPP	To understand and describe tacit knowledge in the NPP context; to study the prerequisites for sharing tacit knowledge in the NPP context	Qualitative, interviews, case studies, inductive content analysis, NPP staff (n = 39)	AACODS 6/6
6	[80]	2011	Journal article Peer-reviewed	Aerospace	To assess instructional strategies used in simulator and on-the-job training for Air Traffic Controllers (ATC); to identify methods of guidance and supervision in ATC training; to show how these methods facilitate trainee participation in core work activities	Qualitative, conversation analysis, ethnomethodology, cross-sectional approach, observations, video recordings, interviews, vocational institute for aviation, simulators with trainees (n = 9), trainers (n = 6), and in two ATC units with trainees (n = 2), and trainers (n = 4)	CASP 8/10 Bias between researchers and sample, sample selection, or ethical issues not adequately described
7	[81]	2012	Report	NPP	To help decision-makers from NPP R&I organizations plan, implement, and sustain knowledge management programs	Qualitative, descriptive, review	AACODS 6/6
8	[48]	2012	Conference paper	Aerospace	To assess a visualization tool to show ATC officers (ATCOs) task processes and tacit knowledge utilization	Quantitative, simulation-based experiment, performance comparison of different control strategies	AACODS 4/6 Methodology, limitations, and sample not adequately described
9	[45]	2012	Journal article Peer-reviewed	Offshore	To assess knowledge generation during the installation, commissioning, and operation of an oil rig; to assess how knowledge is transferred between projects and different user groups; to assess the process of knowledge transfer	Qualitative, explorative, case study, management and crews, audio recording, 18 semi-structured interviews investigating how knowledge transfer was expected to occur across two drilling rigs	CASP 8/10 Bias between researchers and sample, sample selection, or ethical issues not adequately described

(*continued on next page*)

Table 5 (*continued*)

No	Reference	Publication Year	Type	Domain	Aims and Objectives	Methods	Quality Appraisal
10	[46]	2013	Journal article Peer-reviewed	Offshore	To assess loss of experience and knowledge due to retirement and downsizing; to provide guidance to knowledge management as mitigation	Qualitative, explorative, survey, interviews, study on knowledge management practices, sample of 11 global oil and gas companies	CASP 6/10 Bias between researchers and sample, sample selection, or ethical issues not adequately described
11	[82]	2013	Journal article Peer-reviewed	Railway	To assess how train driving skill was acquired and applied; to assess how train simulation could be used to facilitate knowledge acquisition	Qualitative, explorative, semi-structured interviews, observations, document analysis, live and simulator environments, inductive/deductive coding, 6 railway organizations, train drivers, instructors, training managers, (n = 61)	CASP 8/10 Bias between researchers and sample not adequately described
12	[41]	2014	Doctoral thesis	NPP	How professional skills are maintained among NPP operators in relation to requirements of formalized knowledge management	Qualitative, participating observations, open-ended interviews, individual/group, 22 + 24 participants, hermeneutics	AACODS 6/6
13	[47]	2015	Doctoral thesis	Aerospace	To assess the preferences for knowledge capture and transfer among the generations in the ATC workforce, particularly in the training environment	Qualitative, hypothetico-deductive, questionnaire, ATCOs, supervisors, managers, instructors, students (n = 454), descriptive and inferential statistical analysis	AACODS 6/6
14	[83]	2015	Journal article Peer-reviewed	Railway	To assess workplace learning for train drivers in the rail industry; to assess the impact of changes to the traditional learning model; to assess the potential of mentoring in the learning/training model	Qualitative, explorative, semi-structured interviews, grounded theory, 6 railway organizations, train drivers, instructors, training managers, (n = 61)	CASP 8/10 Bias between researchers and sample or ethical issues not adequately described
15	[42]	2017	Conference paper	Control Room	To assess methods for knowledge transfer in process control; to increase awareness of expert operator tacit knowledge; to transfer knowledge into the organization for education and training purposes	Mixed-methods, district heating system operators, interviews with 3 operators, 9 h of observation, and questionnaires to 42 operators	AACODS 6/6
16	[84]	2017	Journal article Peer-reviewed	Offshore	To investigate how companies are handling knowledge retention from retiring workers in the oil and gas sector	Qualitative, exploratory, inductive approach, 15 semi-structured interviews with senior managers, project heads and consultants working in oil and gas companies, thematic content analysis	CASP 9/10 Ethical issues not adequately described
17	[21]	2018	Conference paper	NPP	To develop one method for assessing existing knowledge management processes and one method for elicitation of team-specific collective tacit knowledge facilitating individual and joint learning	Mixed-methods, explanatory sequential design, pilot test, questionnaires, group discussions, interviews	AACODS 6/6
18	[85]	2020	Journal article Peer-reviewed	Aerospace	To assess individual learning within a situated learning framework in terms of Crew Resource Management (CRM) and Situational Awareness (SA) in the context of offshore helicopter in-flight emergency response; to describe and provide guidance on how training can improve CRM performance; to assess how combining	Qualitative, review, explanatory, situated learning as a framework, secondary data	CASP 7/10 Review type of design excludes some criteria for appraisal

(*continued on next page*)

Table 5 (*continued*)

No	Reference	Publication Year	Type	Domain	Aims and Objectives	Methods	Quality Appraisal
					CRM and SA enables the sharing of tacit knowledge		
19	[38]	2022	Conference paper	Maritime	To assess all methods of tacit knowledge transfer during Maritime Pilot Training (MPT)	Mixed-methods, activity theory, observations, semi-structured interviews, questionnaires and document analysis, n = 21, pilot students, pilots, instructors, administrators, coordinators	AACODS 6/6
20	[39]	2022	Conference paper	Maritime	To assess non-technical and informal methods of tacit knowledge transfer during Maritime Pilot Training (MPT)	Mixed-methods, observations, semi-structured interviews, questionnaires, document analysis, field notes, audio recordings, thematic inductive analysis, n = 21 participants, 3 pilot stations, onboard piloting missions, and at a central training facility	AACODS 6/6
21	[86]	2023	Journal article Peer-reviewed	Maritime	To assess ship collision avoidance methodology in terms of tacit knowledge development and collective learning	Qualitative, exploratory, analysis of 1431 recorded VHF radio conversations, field notes, observations, thematic analysis	CASP 7/10 Bias between researchers and sample, sample selection, or ethical issues not adequately described
22	[87]	2023	Journal article Peer-reviewed	Offshore	To assess how outsourcing causes knowledge loss in the oil and gas sector and to assess knowledge retention strategies as mitigation	Qualitative, exploratory, inductive approach, 15 semi-structured interviews with senior managers, project heads and consultants working in oil and gas companies, thematic content analysis	CASP 8/10 Bias between researchers and sample, sample selection, or ethical issues not adequately described

3.3. *Knowledge transfer in safety-critical systems based on the SECI model*

3.3.1. *Socialization*

Tacit-to-tacit knowledge transfer (Appendix A, Table 6) is extensively discussed in the literature. Most studies describe methods for transferring tacit knowledge—knowledge that is non-codified or non-articulated—through shared social experiences, which often require physical proximity and interaction [21,38,39,46]. This dimension encompasses both formal and informal approaches. Formal approaches often include scheduled meetings [80], apprenticeship programs [22,38], cross-training initiatives [22], partnerships with educational institutions [79], vocational learning programs [80], communities of practice [38–40,46,79–81,84–86], observational learning [26,38,82], and peer-learning activities [38,80]. Informal methods include interactions such as casual coffee-break discussions [38,40,42,45,81,84,85], informal social activities [42], and mentoring relationships [82]. Informal social activities, in particular, are emphasized for their role in fostering shared values and building trust. In contexts like the offshore domain and the NPP industry, managing contract workers—both in terms of numbers and timing—remains a critical practice [40,87]. Additionally, strategies such as recruiting long-term employees [46], implementing retiree knowledge retention plans [22], engaging retirees as consultants or

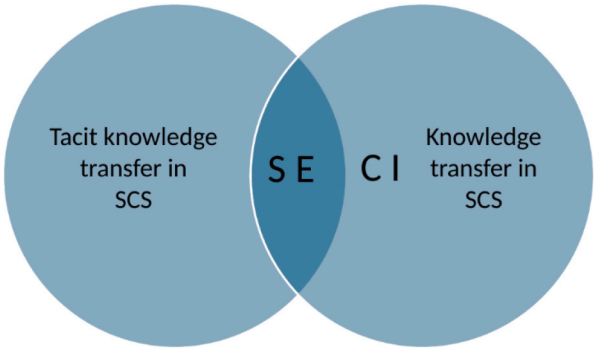

Fig. 3. Description of how the SECI model [1] was used to organise the results from the systematic literature review.

educators [22,40,84], and prioritizing local recruitment [40] are commonly employed to ensure sustainable knowledge transfer.

3.3.2. Externalization

Tacit-to-explicit knowledge transfer (Appendix A, Table 7) is widely discussed in the literature. Most studies describe methods for crystallizing, codifying, and articulating knowledge, thereby making it explicit and shareable with others [88]. This dimension predominantly involves formal methods, such as the use of metaphors or analogies [1,38,40,42,45,84,85,88], storytelling [21,38,40,84,85], exit interviews [84], brainstorming sessions [85], debriefings [38,79,85], diaries [38–40], think-aloud methodologies [26,85], lessons-learned programs [45,81], written instructions [40], the creation of databases or repositories [21,38,39,45–47,79], and individual or group reflections [39]. Although less frequently mentioned, informal methods also contribute to this process, including the use of metaphors or analogies [1,38,40,42,45,84,85,88] and storytelling [21,38,40,84,85].

3.3.3. Combination

Explicit-to-explicit knowledge transfer (Appendix A, Table 8) refers to the process by which explicit knowledge—sourced either internally or externally—is combined, converted, and synthesized into more complex and systematic bodies of knowledge. In this process, discrete elements of explicit knowledge are integrated to form a cohesive whole [1]. Notably, this combination does not expand the knowledge base but rather serves to augment and refine it. Common methods include the use of databases and wikis [21,38,39,45–47,79], guidelines [79], models or mock-ups [39,82], and manuals [45–47], which are often hosted on digital portals [46,84]. In the Information and Communication Technology (ICT) sector, novices tend to rely heavily on such structured systems and formal procedures. In contrast, more experienced personnel are more likely to adopt informal and proactive approaches to knowledge transfer [45].

3.3.4. Internalization

Explicit-to-tacit knowledge transfer (Appendix A, Table 9) involves processes through which explicit knowledge is continuously assessed, reflected upon, and internalized [1,80,86]. Common methods include the use of golden rules [38], best practices [38,46], simulator-based training [22,38–40,80,82,83,85], classroom lectures [38,39,47,82,83], and collaboration software [46,48]. Although best practices are typically articulated and disseminated through explicit means, their transfer is shaped by non-articulated elements that operate at both the level of individual expertise and within organizational routines [46]. These implicit dimensions add depth and complexity to the internalization process.

3.4. Tacit knowledge transfer in safety-critical systems based on the SECI model

Based on the definition of tacit knowledge provided in Section 1.3, relevant findings were extracted from Section 3.3 using the Socialization (Appendix A, Table 6) and Externalization (Appendix A, Table 7) dimensions.

3.4.1. Socialization

In SCS, organizations often facilitate the dissemination of tacit knowledge by establishing formal environments that encourage collaboration, open communication, and systematic feedback. These environments typically integrate practices such as communities of practice, apprenticeships, vocational training, and mentorship [22,26,38–40,46,79,80,82,84–86]. The transfer of tacit knowledge also depends on key elements like individual experience, prolonged exposure to phenomena, practice, physical proximity, and interaction [1,19,21,38,39,46]. Tacit knowledge transfer involves intuitive, experience-based understanding that individuals apply in various activities, though it remains context-specific [16,20]. Efforts to enhance tacit knowledge management in SCS often focus on small, context-rich communities of practice, such as crews or teams, operating in real-life environments or simulators. These settings facilitate the interaction and sharing of experiences between experts and novices, enabling engagement in both routine and non-routine scenarios [21–23,33,38–42,45–48,79–87].

3.4.2. Externalization

In an SCS, organizations manage embedded tacit knowledge by crystallizing, codifying, storing, and articulating it through various methods. Common approaches include briefings [38,79,85], diaries [38–40], think-aloud methodologies [26,85], lessons-learned programs [45,81], written instructions [40], the development of databases or repositories [21,38,39,45–47,79], individual or group reflections [39], scenario analysis [21,26], and focus group evaluations [48]. Additionally, capturing experiential insights through interviews or debriefing sessions following incidents, accidents, or catastrophes supports the conversion of safety-critical knowledge into SOPs, best practices, guidelines, golden rules, or regulations [38,42,45,46,79]. These instruments are essential for maintaining the reliability and effectiveness of safety-critical systems.

4. Discussion

This systematic literature review aimed to develop an understanding of methods for knowledge transfer in general—and tacit knowledge in particular—within SCS, and to evaluate these methods from a methodological perspective. The SECI model, including all four dimensions, was used to examine knowledge transfer, while the socialization (tacit-to-tacit) and externalization (tacit-to-explicit) dimensions were specifically applied to analyze tacit knowledge transfer. The studies included in the review varied in terms of methodology, sample, population, instruments, and overall quality. These variations were anticipated, as the search strategy

intentionally encompassed both empirical and non-empirical (grey) literature. Excluding grey literature would have substantially reduced the number, breadth, and depth of the included studies.

To assess study quality, rigorous critical appraisal methodologies were employed. The CASP was applied to qualitative literature, the MMAT to mixed-methods literature, and the AACODS checklist to non-empirical (grey) literature, with all literature demonstrating acceptable quality. The systematic literature review was guided by PRISMA principles where applicable, which influenced the appraisal process. Methodological implications primarily stemmed from PRISMA's stringent requirements concerning sensitivity, confidence, effect measures, and heterogeneity—standards rooted in medical research. While these criteria may not be fully suited to the present review context, they nonetheless offered a robust framework for evaluating study quality. At the same time, there is a risk of bias arising from the potential overrepresentation of studies with more favourable or novel findings in the published literature. This form of publication bias may lead to the exclusion of relevant studies with neutral or negative results. Additionally, potential language, database, and citation biases may affect the comprehensiveness of the review, particularly if only English-language studies or a limited set of databases were included. Efforts were made to mitigate these risks using multiple databases, backward and forward citation tracking, and inclusion of grey literature where possible. Nevertheless, the possibility of residual bias cannot be entirely ruled out.

4.1. Defining and operationalizing tacit knowledge

The overall findings of this systematic literature review underscore the critical importance of KM, particularly within SCS. Tacit knowledge manifests in diverse forms and often lacks a unified conceptualization or clearly defined research framework, making it difficult—if not impossible—to fully articulate. Consequently, defining and operationalizing tacit knowledge poses two primary challenges.

First, tacit knowledge is associated with varying definitions and closely related concepts, ranging from instinct, intuition, and gut feeling to pattern recognition, know-how, skills, competence, procedural knowledge, procedural memory, and muscle memory. Distinguishing tacit knowledge from these related concepts can be difficult, as they often overlap in practice and their common or operational uses do not necessarily correspond with their academic definitions. This creates a gap between the various expressions of tacit knowledge and the development of research concepts or constructs. None of the studies reviewed provided a comprehensive definition or in-depth exploration of the constitution of tacit knowledge.

Second, operationalizing tacit knowledge presents distinct methodological challenges. Its deeply personal and subjective nature makes it difficult for individuals to articulate and for researchers to capture, interpret, and document. Research instruments such as questionnaires, interviews, and surveys may therefore require individuals to articulate aspects of their knowledge that are inherently difficult or even impossible to fully express. Although such instruments remain valuable for data collection, this resistance to articulation limits the development of reliable metrics and evaluative frameworks for investigating tacit knowledge. These limitations complicate the systematic study of its role in knowledge processes and highlight the need for methodological approaches capable of addressing knowledge that cannot readily be verbalized or codified.

4.2. Transferring tacit knowledge in safety-critical systems

The findings indicate that tacit knowledge transfer in SCS is primarily a social and experiential process, in which practical, hands-on activities and interpersonal interaction play central roles. Communities of practice, apprenticeship, mentoring, and other forms of situated learning enable novices to interact with experienced practitioners and gradually acquire knowledge that may be difficult to articulate or codify. However, neither novices nor experts necessarily gain full insight into the knowledge underlying acquired skills, as important aspects may remain tacit and resist articulation. Thus, tacit knowledge transfer involves not only the transmission of knowledge, but also participation in the practices and social context in which that knowledge is developed and applied.

A central challenge concerns the relationship between formal and informal knowledge transfer. Communities of practice may be formally supported through vocational or apprenticeship programs while simultaneously relying on informal social interaction. Attempts to formalize such interaction may reduce its effectiveness by imposing structure on processes that are inherently spontaneous. In SCS, this creates a particular tension: informal interaction may facilitate tacit knowledge transfer, while informal practices may also go unnoticed and contribute to deviations from established SOPs, potentially compromising safety. Notably, none of the reviewed studies explicitly examined the safety risks associated with informal social learning. Balancing the social conditions that facilitate tacit knowledge transfer with the procedural standardization required in SCS therefore represents an important organizational challenge.

Although many studies examined technical means of supporting knowledge transfer, including ICTs, portals, databases, simulators, and specialized software, interpersonal interaction remained a recurring theme. Technology can support the retention, accessibility, and dissemination of knowledge, but tacit knowledge transfer appears to depend particularly on interaction between individuals. Organizational strategies such as mentoring, succession training, retaining experienced personnel as educators or consultants, and facilitating access to experienced practitioners may therefore complement technological solutions.

Taken together, the findings suggest that effective tacit knowledge transfer in SCS depends less on any single transfer method than on creating conditions in which experience, social interaction, organizational structures, and technological support can operate together without undermining established safety requirements.

Future research on tacit knowledge should address both conceptual and methodological challenges. Greater conceptual clarity is needed regarding the boundaries of tacit knowledge and its relationship to associated concepts such as intuition, pattern recognition, know-how, skills, competence, and procedural knowledge. Particular attention should be given to the conceptual alignment between how such terms are understood and used by practitioners and how they are defined and operationalized in academic research.

Methodologically, future research should move beyond reliance on methods requiring participants to explicitly articulate knowledge that may be difficult to verbalize. Mixed-methods and longitudinal designs combining interviews and questionnaires with observations, performance and behavioural measures, and methods such as eye-tracking may provide a more comprehensive understanding of tacit knowledge in action and how it develops and transfers over time. Research should also examine how formal and informal learning, interpersonal interaction, and technological support interact within SCS, including their relationship with established safety requirements. Comparative studies across SCS domains and professional cultures may further help distinguish context-specific mechanisms from more general principles of tacit knowledge transfer.

5. Conclusion

This systematic literature review examined methods for transferring tacit knowledge within safety-critical systems. To the best of our knowledge, no previous systematic literature review has specifically addressed this topic. The findings identify a range of organizational, social, and technological approaches to supporting tacit knowledge transfer.

Across the reviewed studies, tacit knowledge transfer emerged primarily as a social and experiential process, supported by communities of practice, apprenticeship, mentoring, practical experience, and interpersonal interaction. Although formal knowledge-management strategies and technological solutions can support this process, they cannot fully substitute for the social interaction through which tacit knowledge is developed and shared. In SCS, this creates a particular challenge, as informal knowledge transfer must coexist with requirements for standardization, procedural compliance, and safety.

The review also identified conceptual and methodological limitations, including inconsistent definitions, difficulties in operationalizing tacit knowledge, and limited longitudinal evidence of transfer effectiveness. Greater conceptual clarity and methodological approaches capable of examining tacit knowledge in practice are therefore needed. Despite these challenges, preserving and transferring tacit knowledge remain important for maintaining expertise, organizational learning, and safe performance in SCS.

CRediT authorship contribution statement

Rikard Eklund: Writing – original draft, Project administration, Methodology, Data curation, Conceptualization. **Anna-Lisa Osvalder:** Writing – review & editing, Supervision.

Ethical approval statement

Ethics approval was not required for this study.

Previous dissemination

An earlier version of this work was included in the first author's licentiate thesis [89]. The present manuscript has subsequently been substantially revised and further developed for publication as a journal article.

Data availability statement

The data supporting the findings of this systematic literature review are derived from the publicly available sources cited in the manuscript. No analytic code was used. Additional review materials are available from the corresponding author upon reasonable request.

Declaration of generative AI and AI-assisted technologies in the writing process

During the preparation and revision of this work, the authors used ChatGPT (OpenAI) to support language editing, proofreading, and improvements in clarity and readability. The tool was not used to generate research data, conduct the literature review, perform the analysis, or formulate the scientific conclusions. After using this tool, the authors reviewed and edited the content as needed and take full responsibility for the content of the publication.

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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.

Appendix A. Compilation of findings based on the SECI model

Table 6
Appendix A Compilation of tacit knowledge transfer methods in terms of socialization.

Knowledge transfer method	Reference
APPRENTICESHIP	[22,38]
AUTHENTIC ACTIVITIES	[80]
CAREER TRACKING	[45]
COACHING	[22,79]
COLLATERAL DUTIES	[22]
COMPETENCE TRANSFER PROGRAMS	[40]
COMMUNITIES OF PRACTICE/ACTIVITIES/LEARNING/INTEREST	[38–40,46,79–81,84–86]
CONTRACT WORKFORCE ACTIVITY DOCUMENTATION AND SHARING	[87]
CONTRACTORS	[22]
CONTRACT WORKFORCE RELATIONSHIP MANAGEMENT	[87]
CONTINUOUS RECRUITMENT	[41]
COOPERATION/COLLABORATION	[21,47,79–81,85,86]
CROSS-FUNCTIONAL MULTI-LEVEL TEAMS	[87]
CROSS-TRAINING	[22]
DOCUMENTATION	[87]
DYNAMIC ALLOCATION OF TASKS DURING AUTOMATION	[33]
EARLY RECRUITMENT	[23]
EXIT INTERVIEWS	[84]
EXPERIENTIAL LEARNING	[46]
EXPERTS AS TRAINERS	[79]
EXPLORING SYSTEMS DURING REVISIONS OR SERVICE	[40,45]
FACE-TO-FACE INTERACTION	[47,79]
FORMAL MEETINGS	[80]
FREE-TIME ACTIVITIES	[38]
FUTURE ATTRITION PROJECTS	[22]
GOOD RELATIONS BETWEEN CONTRACT WORKFORCE AND EMPLOYEES	[87]
GROUP LEARNING	[86]
GUIDANCE	[80]
HANDS-ON EXPERIENCE	[33,38,39,80,82]
HIRING CONTRACTORS AS PERMANENT EMPLOYEES	[87]
IMITATION	[83]
INFORMAL MEETINGS	[38,40,42,45,84,85]
INFORMAL MENTORING	[83]
INFORMAL SOCIAL ACTIVITIES	[42]
INFORMAL TRAINING	[33]
INSTRUCTOR TIME AND TRAINING ALLOCATION	[23]
INTERACTIVE GROUPS	[46]
INTERACTION WITH REMOTE OTHERS	[86]
INTRODUCTION PLANS	[40]
JUNIOR STAFF PARTICIPATION ON ALL ORGANIZATIONAL LEVELS	[79]
KNOWLEDGE CAFÉ	[81]
KNOWLEDGE SHARING CULTURE	[79]
LEARNING BY ACTING AS A TEACHER	[40]
LEARNING IN SOCIAL SITUATIONS	[39]
LEARNING ON THE JOB	[22,47,79,80,82,83]
LEARNING THROUGH PRACTICE	[80,86]
MAINTENANCE STAFF DRAFTED AS CONTROL ROOM OPERATORS	[33]
MAKE PEOPLE STAY STRATEGIES	[46]
MEDIATED CO-PRESENCE	[86]
MENTORING	[21,22,40,42,47,83,84]
MULTIPLE SKILLS ACQUISITION	[22]
NATURAL WORKING ENVIRONMENT TRAINING	[82]
OBSERVATION	[22,38,42,81,82]
OPERATIONAL VISITS	[45]
ORGANIZATIONAL CULTURE AND POLICY	[87]
OTHER SITES TRAINING	[22]
OVERLAPPING RETIREES AND NEWLY EMPLOYED	[40]
PARALLEL WORK	[40]
PARTICIPATION	[86]
PARTNERSHIP WITH EDUCATIONAL INSTITUTIONS	[79]
PART-TIMERS	[22]
PEER ASSIST	[47,81]
PEER LEARNING	[38,80]

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Table 6 (*continued*)

Knowledge transfer method	Reference
PEER REVIEW	[46,84]
PEER TEAMS	[22]
PERIODIC REVIEWS	[22]
PERSON-TO-PERSON	[46]
PRIORITIZING PEOPLE TO PROJECT SIZE AND COMPLEXITY	[87]
PRACTICAL SKILLS REQUIRED FOR OPERATORS	[41]
PROXIES AND SUBSTITUTES ASSIGNED	[79]
RECRUITING STAFF FROM LOCAL COMMUNITIES	[41]
RECRUITING AND TRAINING THE RIGHT PEOPLE	[46]
REAL-LIFE TASKS	[86]
REGULATING NUMBER OF CONTRACT WORKFORCE	[87]
REHIRED WHEN REQUIRED POLICY	[87]
RELATIONSHIP MANAGEMENT BETWEEN NOVICE AND EXPERT	[23,80]
RETIREE KNOWLEDGE RETENTION PLANS	[22]
RETIREES AS CONSULTANTS	[84]
RETIREES RETURN AS PART-TIME WORKERS	[22,40]
RETIREES RETURN AS TEACHERS	[22,40,84]
ROTATING EMPLOYEES	[38,45,46]
SHADOWING	[22]
SHARED ACTIVITY	[86]
SHARED EXPERIENCES	[21,85]
SHARED RESOURCES	[22]
SITUATED LEARNING	[39]
SITE EXPERT	[22]
SOCIAL ACTIVITIES	[42]
SOCIAL LEARNING	[86]
SOCIALIZATION	[86]
STAFF LOSS ASSESSMENT	[22]
STORYTELLING	[21,38,40,84,85]
SUCCESSION PLANNING	[79]
SUPERVISION	[80,87]
TARGETED WORK ASSIGNMENTS	[22]
TARGETED RECRUITMENT	[22]
TEAMWORK	[79]
TEMPORARY ALLOCATION OF CREWS	[45]
VIRTUAL COMMUNITIES	[46]
VIRTUAL PEER ASSIST	[84]
VIRTUAL TEAMS	[46]
VOCATIONAL TRAINING	[80]
WORKFORCE PLANNING	[79]
WORK ROTATION	[40]

Table 7
Appendix A Compilation of tacit knowledge transfer methods in terms of externalization.

Knowledge transfer method	Reference
ANALYZING AND DISCUSSING EVENTS AND NEAR-MISSES	[79]
ARTICULATE INFORMATION	[85]
ARTICULATING REASONING	[85]
BRAINSTORM	[85]
BRIEFINGS/DEBRIEFINGS	[38,79,85]
CASE STUDY BOOK	[85]
COMMUNICATION AMONG COLLEAGUES	[45]
CONFERENCES	[46]
DEBRIEFING SESSIONS RECORDED ON VIDEOS	[84]
DIALOG METHODS	[40]
DIARIES	[38–40]
DIRECTED SELF-STUDY	[22]
DISCUSSION GROUPS	[21,40]
EVALUATING AND DOCUMENTING EXPERIENCES FROM SIMULATOR TRAINING	[79]
EVALUATION INTERVIEWS	[79]
GATHERING COMMENTS	[45]
INDIVIDUAL OR GROUP REFLECTIONS	[39]
INFORMAL NETWORKS	[46]
INTERVIEWS	[81,84]
LESSONS-LEARNED PROGRAMS	[45,81]
NETWORKING	[26,84]
ONLINE COMMUNITIES	[84]
OPEN DISCUSSIONS	[85]

(*continued on next page*)

Table 7 (*continued*)

Knowledge transfer method	Reference
PERSONAL NETWORKS	[45]
REFLECTION IN GROUPS	[38]
PRE- AND POST-JOB WORKSHOPS	[21]
REFLECTION-PROMOTING QUESTIONS	[21]
RECORD BOOK OF STUDIES	[86]
REUSE OF PROCEDURES	[45]
ROLE-PLAY	[42]
SELF-INTERVIEWING	[21,81]
SELF-REPORT	[85]
SEMINARS	[40,46]
SOCIAL MEDIA	[47]
SOCIAL NETWORKS	[47,81,84]
SYSTEMATIC EXCHANGE DURING JOB EXECUTION	[21]
THINK-ALOUD METHODOLOGY	[26,85]
VIDEO CONFERENCES	[46]
WRITTEN INSTRUCTIONS	[40]
WORKSHOPS	[21,45,46]

Table 8
Appendix A Compilation of tacit knowledge transfer methods in terms of combination.

Knowledge transfer method	Reference
BULLETIN/MESSAGE BOARDS	[46,47]
CAUSAL MAPPING	[21]
COMPUTER NETWORKS	[79]
COMPANY YELLOW PAGES	[46]
CONCEPT MAPPING	[22,81]
CORPORATE MEMORIES	[46]
DATABASES/LIBRARIES/DIRECTORIES/CATALOGS/TAXONOMIES/WIKIS/RECORDS	[21,38,39,45–47,79,81]
DOCUMENTING AND CODIFYING EXPLICIT PROCEDURES	[22,45,79]
DOCUMENTS	[79]
EXPERT LOCATOR	[23,46]
EXPERT NETWORKS	[84]
FILM/ANIMATION/AUDIO/VIDEO/DRAWINGS/GRAPHICS/PHOTOGRAPHY	[22,38,39,42,45,79]
FOCUS GROUP MEETINGS	[48]
FREQUENTLY ASKED QUESTIONS (FAQ)	[46]
GUIDELINES	[79]
ICT	[38,45–47,79,81]
IDENTIFYING INITIATIVES	[19]
INCIDENT REPORT SYSTEMS	[42]
INTERVIEWS	[21,85]
INSTRUCTIONS	[38–40,80]
INVENTORIES	[79]
JOB AIDS	[79]
KNOWLEDGE BOOK ON PORTAL	[84]
KNOWLEDGE CHAMPIONS	[46]
KNOWLEDGE MARKETPLACE	[81]
LESSONS LEARNED	[46,84]
LITERATURE	[38,39]
MANUALS	[45–47]
PORTALS	[46,81,84]
PROCESS MAPPING	[81]
QUESTION BANKS	[79]
REFERENCE LIBRARIANS/HELP DESK	[46]
REPORTS	[84]
SCENARIO ANALYSIS	[21,42,82]
SHARE POINTS	[84]
SHARING INFORMATION	[47]
SOFTWARE	[45,79]
STEPWISE QUESTION-BASED DEEPENING APPROACH	[21]
TRANSFER OF RECORDS	[45]
WEBSITES	[79]

Table 9
Appendix A Compilation of tacit knowledge transfer methods in terms of internalization.

Knowledge transfer method	Reference
CHECKLISTS	[22,42]
COMPILATIONS OF HEURISTICS AND PROBLEM-SOLVING STRATEGIES	[42]

(*continued on next page*)

Table 9 (*continued*)

Knowledge transfer method	Reference
COMPUTER- AND VIDEO-BASED TRAINING	[22]
COORDINATED LEARNING	[80]
DESK GUIDE	[79]
DOCUMENTS	[47]
FAQ	[47]
GOLDEN RULES/HEURISTICS/GUIDELINES/BEST PRACTICES	[38,46]
HANDOUTS	[39]
HANDOVER PROCEDURES	[45]
ICT	[47]
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