A Community Roadmap for Meta-Research and Knowledge Transfer in Software Engineering

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Abstract

This paper presents a strategic direction in terms of work in progress of a newly formed working group focused on meta-research (meta-science) in software engineering (SE), with a particular emphasis on meta-research and bridging research and industrial practice. Originating from a collaborative workshop with researchers and practitioners, the paper synthesizes the participants' contributions and requests into a structured set of topics that reflect current needs, challenges, and future opportunities in empirical and evidence-based SE, reproducibility, open science, and research data infrastructures. The derived roadmap outlines the group's commitment to foster transparency, sustainability, and methodological rigor in SE research. It also highlights the importance of cross-sector collaboration in research and practice to ensure relevance and impact. The paper introduces a thematic roadmap derived from the workshop outcomes and positions it as a basis for future joint activities, including publications, tool development, and community engagement. By formulating shared goals and outlining actionable next steps, this paper aims to establish a common understanding and invite broader participation in shaping the future of meta-research and infrastructures in SE, embedded in existing initiatives.

CCS Concepts

• **General and reference → Surveys and overviews**.

Keywords

Meta-research, Knowledge Transfer, Research Data Management

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1 Introduction

Meta-research (research on research) [9] has gained increasing relevance in software engineering (SE) research, particularly in the context of reproducibility, transparency, and the transfer of knowledge between research and practice. As SE research becomes more data-driven and collaborative, the need for structured reflection on research practices, methodologies, and sustainable infrastructures has grown. Critical questions arise: Are our research practices keeping pace with our ambitions? How can we ensure that research findings effectively transfer to industrial practice? Can we build sustainable infrastructures that support both rigor and relevance?

This paper combines a position on the role of meta-research in SE with an account of work in progress on establishing a dedicated working group. We present the foundational principles and strategic vision of this newly formed working group, with a specific focus on fostering sustainable collaboration between research and industry. The paper is grounded in the outcomes of a community-driven workshop, in which participants from diverse SE backgrounds shared their perspectives and priorities. Through structured discussion and thematic clustering, a consolidated list of topics was developed, reflecting shared interests and challenges, as well as current work in empirical and evidence-based SE, open science, tooling, research dissemination, and discovery. These topics form the basis for the working group's agenda and serve as a roadmap for future joint activities with related initiatives.

Our goal is to articulate a common understanding of the role and potential of meta-research in SE, define guiding principles for the working group, and outline actionable next steps. By doing so, we aim to promote methodological rigor, foster interdisciplinary exchange, and strengthen connections between academic research across various initiatives and industrial practice, while advancing sustainable research data management and infrastructure.

We provide the materials of the working group via an open-access repository: https://gitlab.com/software-engineering-meta-research/gi-working-group.

2 Background

In this section, we introduce relevant terms for the remainder of this position paper. These concepts form the foundation for understanding how meta-research findings can be systematically transferred and applied to improve SE research practices.

Meta-research / Metascience. Meta-research / Metascience, or research on research, studies how researchers conduct, communicate, and evaluate scientific work [9]. It aims to improve research quality, efficiency, and transparency by analyzing methodologies, publication practices, peer review, reproducibility, and incentives. By revealing systemic strengths and weaknesses, meta-research supports evidence-based improvements in science and its governance.

Open Science & FAIR Principles. Open Science in SE promotes transparency, accessibility, and reuse of all research components like data, code, and publications, fostering collaboration, reproducibility, and accountability [17]. The FAIR principles (Findable, Accessible, Interoperable, Reusable) guide the management of research artifacts to support both human and machine access for data [20] and software [4]. Applied in SE, they help ensure that researchers document, standardize, and make datasets and tools reusable, strengthening the sustainability and impact of empirical research. Together, they enable more robust and community-driven SE practices.

Research Data Management. Research Data Management (RDM) involves the systematic handling, documentation, sharing, and preservation of research data across the research lifecycle. In SE, this includes artifacts like code, models, datasets, and experiment logs. Effective RDM supports transparency, reproducibility, and FAIR data practices, enabling collaboration, compliance with ethical standards, and the long-term value of empirical research.

Conclusion. Together, these interconnected concepts, i.e, meta-research as the analytical lens, Open Science and FAIR principles as guiding frameworks, and RDM as the practical implementation, form a comprehensive ecosystem for enhancing research quality and facilitating knowledge transfer in SE.

3 Related Initiatives

In this section, we present initiatives related to our working group.

NFDIxCS and EOSC. To promote Open Science and FAIR principles (Section 2) as well as sustainable research data management (RDM), the National Research Data Infrastructure[1] (NFDI) systematically organizes, standardizes, and makes accessible research data across all disciplines in Germany. NFDI currently comprises 26 domain-specific consortia[2], complemented by the cross-cutting consortium Base4NFDI[3], which provides foundational services. Additionally, NFDI contributes to international initiatives such as the European Open Science Cloud (EOSC)[4]. The overarching goal is to establish a sustainable and interoperable infrastructure for long-term data preservation, accessibility, reuse, and interdisciplinary integration. The consortium *National Research Data Infrastructure for and with Computer Science (NFDIxCS)*[5] specifically addresses the challenges and requirements of research data management in computer science and SE.

The International Software Engineering Research Network (ISERN). ISERN[6] plays a central role in shaping the empirical foundations of SE. As a global community of researchers and practitioners, ISERN promotes rigorous empirical methods that enhance the quality, relevance, and impact of SE research. Its primary objectives include fostering collaboration across institutions and countries, encouraging replication and reuse of empirical studies, and supporting methodological innovation through shared frameworks such as the Quality Improvement Paradigm. ISERN facilitates knowledge exchange between academia and industry, bridging the gap between theoretical insights and practical applications. Through annual meetings, workshops, and joint initiatives, the network provides a platform for discussing challenges, sharing best practices, and developing new approaches to evidence-based SE.

Common Goals and Demarcation. NFDIxCS and ISERN are two influential initiatives in the research ecosystem that advance research practices in computer science and SE. Each has a distinct scope, yet they share complementary goals that offer opportunities for mutual benefit. In this context, our working group on "Meta-Research and Knowledge Transfer in SE" is strategically positioned to complement and connect the objectives of both initiatives. The group focuses on the cooperative development of new solutions and on facilitating structured knowledge exchange across the SE community.

4 Workshop Session

In the following section, we describe the workshop session and sketch its outcomes before deriving a roadmap in Section 5.

4.1 Organization and Conduction

To initiate the formation of our working group[7] within the SE community and beyond, a structured working session was conducted with the FGARC-JT-25[8], i.e., the annual conference of the GI[9] special interest group software architecture (SWA), during a collaborative workshop. The session aimed to identify state-of-the-art and state-of-practice, shared interests, challenges, and actionable research directions. This was achieved by engaging participants in a multi-phase, interactive format. Three members of the working group moderated the workshop. Participants in the workshops represent both academic (all career stages) and industrial backgrounds.

The workshop followed a structured five-phase approach to systematically gather community input:

Phase 1: Impulse Presentation. The session began with an impulse presentation that provided an overview of current initiatives and emerging opportunities in meta-research. Key topics included: (1) community standards like the *ACM Empirical Standards*[10] and

[1]https://www.nfdi.de/association/?lang=en [Last accessed on 2025-10-10]
[2]https://www.nfdi.de/consortia/?lang=en [Last accessed on 2025-10-10]
[3]https://base4nfdi.de/ [Last accessed on 2025-10-10]
[4]https://open-science-cloud.ec.europa.eu/ [Last accessed on 2025-10-10]
[5]https://nfdixcs.org/ [Last accessed on 2025-10-10]
[6]https://isern.iese.de/ [Last accessed on 2025-10-10]
[7]https://ak-se-meretra.gi.de [Last accessed on 2025-10-10]
[8]https://gi.de/veranstaltung/architekturen-2025 [Last accessed on 2025-10-10]
[9]The German Informatics Society (GI) is the largest interest group for computer science in the German-speaking area: https://gi.de/
[10]https://www2.sigsoft.org/EmpiricalStandards/ [Last accessed on 2025-10-10]

collaborative efforts within *ISERN* (Section 3), (2) the role of large language models (LLMs) in SE and meta-research, including the development of LLM usage guidelines [18] and best research practices for responsible and sustainable AI [12], (3) semantic classification and machine-readable representation of SWA research [15, 16], with reference to FAIR-aligned infrastructures such as the *Open Research Knowledge Graph (ORKG)*[11] and *dblp kg*[12], and (4) opportunities for study replication and artifact evaluation, particularly through automated support via LLMs and submission systems.

Phase 2: Participant Engagement. Following the presentation, participants took part in a collective icebreaker to share their backgrounds, meta-research interests, preferred roles or tasks, and expectations for future developments in the field. This phase served to establish a shared understanding of participants' motivations and expertise.

Phase 3: Collaborative Ideation. Ideas were collected collaboratively using a digital Miro board. This allowed participants to contribute and cluster suggestions in real time, facilitating open brainstorming and visual organization of emerging themes.

Phase 4: Group Discussion. An open discussion followed, in which participants reflected on the collected ideas, identified thematic overlaps, and proposed initial directions for structured topic development. This phase emphasized consensus-building and refinement of community priorities.

Phase 5: Post-Workshop Aggregation. To ensure persistence and traceability of the outcomes, we conducted a post-workshop coding phase. We aggregated, categorized, and documented the collected ideas to form a structured topic list. This list serves as the foundation for the working group's future agenda and collaborative efforts.

Workshop Materials. All materials of the workshop session are openly available via our open-access repository[13].

4.2 Outcomes

Based on the outcomes of a collaborative workshop, this section outlines key thematic areas identified by participants as priorities for future research and infrastructure development in the context of meta-research, reproducibility, and the intersection of academia and industrial practice. The following four main themes emerged from the authors' post-workshop aggregation and categorization process.

4.2.1 Review Processes and Artifact Evaluation. Peer review remains essential for assuring the quality of papers and supplementary materials, yet it is time-consuming and lacks standardized support. To address these challenges, workshop participants proposed: (1) developing tools to help reviewers work more efficiently and enhance review quality, (2) establishing community-wide standards for reviewers and authors to ensure consistency and transparency, (3) creating and maintaining practical guidelines to support both roles, and (4) requiring conferences and journals to collect specific submission metadata and adopt a standardized PDF-based format for post-publication search and filtering.

4.2.2 Industry Relevance and Knowledge Transfer. To strengthen the connection between research and industrial practice, the participants identified the following objectives: (1) classifying research artifacts by their reproducibility from an industry perspective, (2) improving access to research outputs—not only open-source tools but also clear explanations of underlying concepts and methods, and (3) enhancing knowledge-transfer mechanisms between academia and industry, emphasizing reproducibility and applicability across diverse contexts.

4.2.3 Integration of Large Language Models. The increasing use of LLMs in SE raises new questions about transparency and reproducibility. Key directions include: (1) categorizing the use of AI across SE activities (e.g., code generation, requirements analysis), (2) investigating reproducibility challenges with non-deterministic tools, and (3) exploring the potential of LLMs for accelerating systematic literature studies.

4.2.4 Infrastructure and Services. Robust infrastructure is essential for sustainable research data management and artifact reuse. The community identified the following needs: (1) semantically linking research artifacts, (2) sharing infrastructure for managing SWA-related artifacts, (3) extracting and integrating information from heterogeneous scientific sources, (4) developing tools to help researchers identify relevant venues based on problem descriptions or research ideas, and (5) establishing a classification framework for applying FAIR principles in context to enable automated categorization and enhance transparency.

These four thematic areas represent the collective priorities and objectives of the workshop participants and reflect both immediate needs and long-term efforts for the field. They form the basis for the working group's strategic roadmap, which we present in Section 5. The roadmap translates these themes into indicators for concrete actions, future milestones, and collaborative initiatives designed to advance meta-research practices in SE.

5 Roadmap

This roadmap outlines strategic directions and actionable recommendations derived from the collaborative discussions and insights gathered during the workshop. The outcomes reflect a shared understanding of current challenges, emerging opportunities, and priority areas for advancing research practices and infrastructure in SE. By synthesizing diverse perspectives from participants across SE subdisciplines and roles, the roadmap guides future developments in a structured, community-aligned manner. It fosters innovation, interoperability, knowledge transfer, and sustainable impact within the research ecosystem, as indicated in the translational framework for meta-research according to Hardwicke et al. [9].

[11]https://orkg.org/ [Last accessed on 2025-10-10]
[12]https://github.com/dblp/kg [Last accessed on 2025-10-10]
[13]https://gitlab.com/software-engineering-meta-research/gi-working-group/meeting-minutes/meeting-minutes_2025-06-27 [Last accessed on 2025-10-28]

5.1 Review Processes and Artifact Evaluation

Building on the outcomes of the workshop session (Section 4), the first thematic area concerns review processes and artifact evaluation, with the goal of advancing and streamlining them. Thus, it consists of two directions: *guidance on processes and reviewing* and *supporting infrastructure*. On the one hand, guidance means building a common process model with a framework for community-definable review criteria and with best practices for authors and reviewers. On the other hand, review processes and artifact evaluation shall be supported by infrastructure services that assist with various tasks. This includes, for instance, the flexible and simple organization and administration of processes, (semi-)automatic checks of review criteria, and easier access to artifacts and their execution by using cloud-based IDEs[14]. Several aforementioned points of both directions are currently in development in the context of the NFDIxCS Artifact Evaluation Platform[15] [2].

5.2 Industry Relevance and Knowledge Transfer

Addressing the workshop participants' emphasis on strengthening the connection between research and industrial practice (Section 4), this thematic area focuses on improving mechanisms for knowledge transfer. The industry continuously seeks SE concepts and technologies that can deliver tangible value in the near term or the foreseeable future. However, knowledge transfer between academia and industry faces key tensions. While industry stakeholders recognize the value of sharing their practical knowledge with the SE research community, enabling researchers to address real-world challenges and improve solutions grounded in actual organizational contexts, they must also protect business secrets and proprietary assets that provide competitive advantages. Building trust and demonstrating tangible value through actionable research results, such as well-documented SE concepts and accessible tools, offers a pathway to overcome these challenges and foster effective knowledge transfer.

To assess the actual value generated by a proposed approach, industrial stakeholders require means to directly comprehend, evaluate, and engage with research artifacts. This requires providing comprehensive documentation, practical examples, and executable prototypes suitable for experimentation. Additionally, clearly articulating foundational concepts and intended usage, along with providing accessible communication channels to researchers, supports effective knowledge transfer.

Compliance with the FAIR principles [20] [4] can help industry stakeholders to adopt research results. Adhering to these principles ensures that artifacts are efficiently discoverable, free from technical and legal access barriers, integrable into existing industrial workflows, and adaptable for diverse application environments. Moreover, actionable SE research invites practical software engineers to experiment with the research results: implementation and validation steps should be explicit and replicable by others to enable transparent evaluation of practical benefits. Alignment with these principles lowers the barrier between industry and research results and, in turn, helps researchers connect with industry, fostering reproducibility across larger contexts and sustained impact.

[14]https://nfdixcs.org/meldung/artifact-evaluation-in-the-context-of-nfdixcs [Last accessed on 2026-01-14]
[15]https://ae.nfdixcs.org/ [Last accessed on 2026-01-14]

5.3 Integration of Large Language Models

The third key thematic area, identified by workshop participants as critical for future SE research (Section 4), deals with the integration of LLMs across two application scenarios: AI for Software Engineering (AI4SE) and AI for Research (AI4Research). The increasing integration of LLMs into SE research and practices presents both transformative opportunities and pressing challenges while addressing critical concerns around usefulness of AI, non-deterministic character, transparency, reproducibility, and sustainability.

5.3.1 Research Directions for AI4SE. A structured taxonomy is needed to classify the diverse applications of AI in SE. This includes, but is not limited to: code generation and completion, requirements elicitation and analysis, bug detection and resolution, test case generation, software documentation and summarization as well as automating architectural knowledge management [14]. Establishing such categories will support clearer benchmarking, facilitate reproducibility, enable targeted improvements and identify anti-patterns (i.e., where AI is not useful for the aforementioned tasks). Based on this taxonomy, we aim to develop a comprehensive knowledge base that catalogs AI applications, their effectiveness, and best practices across different SE contexts.

5.3.2 Research Directions for AI4Research. LLMs offer promising capabilities to accelerate systematic literature studies by automating tasks such as classification and summarization of research articles. To ensure responsible use, the roadmap emphasizes transparent documentation of LLM-assisted review processes and advocates validating model outputs against human-curated benchmarks to maintain scientific rigor and reliability.

5.3.3 General Research Directions. Reproducibility remains a key challenge when using non-deterministic tools like LLMs, which can generate varying outputs even under similar conditions. To address this, the roadmap calls for standardized documentation of model configurations, prompts, and outputs, the establishment of reproducible workflows, and the adoption of versioned datasets and models to support consistent experimentation. Given the substantial environmental impact of training and deploying LLMs, the roadmap also highlights the need for sustainable research practices (see Kaplan et al. [12]). This includes reporting energy consumption in publications, prioritizing efficient model architectures, leveraging green computing resources alongside carbon offset strategies, and incooperating to emerging LLM guidelines (see Wagner et al. [18]).

5.4 Infrastructure and Services

The fourth thematic area reflects the workshop community's recognition that robust infrastructure is essential for sustainable research data management and artifact reuse (Section 4). One of the main upcoming challenges is to harmonize the community-driven developments in NFDI or EOSC into an overall Research Data and Software Management infrastructure. In the following, we address several dimensions: **architecture**, **services**, **semantic aspects**, **archiving**, and **funding**.

5.4.1 Architecture. One of the key requirements for the architecture is to unify the wide variety of tools by determining which services lie in the core of multiple research areas and how to maintain connections to existing or upcoming services from other initiatives. Within NFDI, Base4NFDI has been established to support services relevant to different communities. Additionally, ongoing discussions have started about the overall architecture of NFDI [19].

5.4.2 Services. Services are necessary to support researchers and institutions in complying with Open Science principles. There are many different approaches regarding where to start and how to offer support, but it is important to couple these tools with local library services and community activities. Libraries need to embrace the new challenges of using existing tools to archive research artifacts. Research communities need to be open not only to publishing and badging research artifacts with their metadata, but also to implementing practices of reusing and replicating formerly presented research artifacts. Similar to testing and evaluating ideas in paper publications, there is also the need to test and evaluate former research artifacts to maintain them as community knowledge [7].

5.4.3 Semantic Aspects. Achieving reproducibility and transparency in SE research requires more than technical infrastructure: it demands a shared semantic understanding of research artifacts and processes. The roadmap emphasizes the need for predefined vocabularies and semantic technologies to ensure that concepts, methods, and results are consistently described and interpreted across studies and domains. This semantic foundation is critical for enabling meaningful comparisons, facilitating reuse, and supporting automated reasoning. For instance, the REFSQ (first edition 2024) and ICSA[16] (first edition 2026) open science challenges have highlighted the importance of artifact annotations to foster such understanding. Annotating research outputs with standardized semantic metadata improves accessibility and traceability while aligning with open science principles. To advance this vision, the roadmap encourages SE research domains to adopt semantic annotation practices. In software architecture, the paper "Evaluation methods and replicability of software architecture research objects" [16] demonstrates how to structure research artifacts (papers, replication packages) and offers a valuable blueprint for extending semantic approaches to other research areas in SE. Establishing cross-domain standards and tooling can help build a more integrated and transparent research ecosystem, ultimately strengthening the scientific foundations.

5.4.4 Archiving and Long-Term Preservation. Archiving research artifacts that were published alongside a paper is one of the main challenges. Producing research artifacts that comply with the FAIR principles requires effort from three groups: the researcher, the community, and the infrastructure. The researcher must be aware of these principles and be willing to comply. The community needs to define a vocabulary to describe the research artifacts, establish interoperability standards for communicating with research software, and set up registries to publish the artifacts. The infrastructure needs to be developed, maintained, and funded. In NFDIxCS, an approach is currently being developed that allows users to create Research Data Management Containers [8] through a structured creation workflow [3] that provides guidelines for constructing and annotating research artifacts. This workflow can be set up uniquely for each research community, providing sufficient flexibility to customize relevant metadata and enabling the presentation of human- and machine-readable output.

Long-term preservation, especially when including research software, is highly challenging because software can rot [13] and different parts of the scientific software stack [10] can alter. Various approaches address this challenge by preserving the execution environment itself, such as the Reusable Execution Environment (REE) [11]. There is a need to create a usable entry point that allows researchers to create a REE. Questions remain about whether the full stack must always be archived and how to set up processes to switch container technologies if needed. Once we have a well-structured and funded infrastructure landscape, the agreement to be open and FAIR, and established archiving practices, we must consider: Do we really need to archive all research output? How do we determine which artifacts need to be maintained and which do not need to be archived?

5.4.5 Funding. The funding perspective is essential for archiving practices because archives are not funded for the time span required for archiving, which in Germany is about 10 years [5]. Within the NFDI, there was a very generous funding period of 5 plus 5 years, but only for two of the three funding rounds. There are ongoing discussions about how to continue this great effort after the funding period. The evaluation report from the German Science and Humanities Council [6] offers hope that funding could be continued if there is political agreement.

5.5 Cross-Cutting Topics

To conclude this section, we identified cross-cutting research directions and necessary steps to drive development and progress in the topics above.

5.5.1 Community Engagement. Transforming the research ecosystem to realize the topics above critically depends on active community engagement and broad acceptance in the SE research community. To support this transformation, our working group will initiate targeted outreach activities (e.g., workshops and webinars) to build awareness, foster trust, and collaboration across disciplines and initiatives. The (co-)development of new solutions with community input will ensure their relevance, usability, and alignment with real-world needs. Furthermore, strategic partnerships and structured training programs (see Section 5.5.2) will promote long-term sustainability and facilitate widespread adoption of emerging practices and infrastructures.

5.5.2 Fostering Competencies. The proposed solutions and the fragmentation of new research directions necessitate education and competency-building. While these solutions and research directions provide means to support SE research, their successful application benefits from educated and informed researchers and practitioners. By developing and offering open trainings, training programs, and self-learning materials, aligned with existing initiatives such as RDMTraining4NFDI[17] from Base4NFDI, specific competencies

[16] https://gitlab.com/software-engineering-meta-research/open-science-challenge-in-software-architecture-research [Last accessed on 2026-01-29]

[17] https://base4nfdi.de/projects/rdmtraining4nfdi [Last accessed on 2026-01-29]

for the different thematic areas (e.g., AI literacy or artifact evaluation [1]) can be fostered. In addition, when programs and materials are accessible and findable through a single central entry point, the barrier for researchers and practitioners to find appropriate training for their targeted competencies is reduced.

6 Conclusion and Next Steps

In this paper, we presented a roadmap for SE meta-research and knowledge transfer, synthesized by the author group based on the discussions and outcomes of a workshop session conducted by a newly established GI working group. The topics discussed in the workshop may be temporal, reflect trends specific to 2025, and be limited in their holistic scope. Addressing these limitations is a core objective of the next phase. The working group will proceed with a structured prioritization of the identified thematic areas and their systematic integration into broader conceptual frameworks, research infrastructures, and strategic objectives of related initiatives. At the next working group meeting, concrete milestones, responsibilities, and dependencies will be defined to enable targeted implementation. While the workshop was conducted in a primarily national context, the roadmap is explicitly designed to align with and contribute to international research agendas and standards. The working group actively aims at international engagement to strengthen interoperability, relevance, and sustainability. Given the rapid evolution of the field, the roadmap will be regularly reviewed and updated, and is therefore understood as a living document that will be continuously refined through coordinated national and international collaboration. The aforementioned open access repository (see Section 1) documents all progress.

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