



# A Functional Classification and Feature Repository for Participative Enterprise Modelling Tools: An AI-Complemented Multivocal Literature Review

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## ABSTRACT

Selecting appropriate modeling tools for participative enterprise modeling (PEM) remains challenging in an era defined by digital collaboration and remote work, partly due to the absence of a comprehensive overview of tool features. To address this gap, we conducted a multivocal literature review (MLR) to develop a repository of PEM tool features. Thirteen primary publications were analyzed, sourced from four academic databases, complemented by searches in SciSpace, Elicit, and through forward and backward snowballing. Some tools identified in academic literature are no longer freely available, and many popular collaborative whiteboard tools were not extracted from our primary publications. To address this, features from grey literature were reviewed and used to enhance our repository. As a secondary contribution, we explore the potential of artificial intelligence (AI) to support the process. Future work should prioritize ongoing updates to the repository and the use of automated methods for literature screening and feature extraction.



## KEYWORDS


Collaborative modeling; participative enterprise modeling; multivocal literature review; tool selection

## 1. Introduction

In today's world, decision makers are increasingly challenged by the overwhelming number of software products available for a wide range of applications. Whether selecting an artificial intelligence (AI) tool to support the systematic review process (Bolaños et al., 2024; Fabiano et al., 2024), selecting software packages (Jadhav & Sonar, 2009; ŞEn et al., 2009), or selecting software tailored to specific contexts (Nursal et al., 2016; Riemer et al., 2011), the abundance of options can complicate the decision-making process. The process of choosing a tool is time consuming (Fleche et al., 2014; Martinez & Stackpole, 2024) and cognitively demanding, described as navigating a “jungle of options” (Weiseth et al., 2006, p. 239). Given these challenges, selections are often based on convenience or familiarity rather than fit for purpose (Prikladnicki et al., 2022).

An example of digital tools that are very relevant today are distributed collaborative modeling tools. During Covid-19, people were forced to significantly reduce their physical interactions which lead to an embrace of *online*, or remote, interaction and applications (Aleem et al., 2023; Prikladnicki et al., 2022). There is also an increase in people working collaboratively to achieve a common goal (Andrés et al., 2016) with the usage of graphical representations of aspects of an organization, via enterprise models, becoming increasingly important and valuable for modern organizations (Prilla et al., 2013; Vernadat, 2020). Companies are therefore increasingly adopting new, online tools such as digital whiteboards or diagramming tools as these tools make it easy for remote team members to collaborate together in real-time (Prikladnicki et al., 2022). The right modeling tool fosters better collaboration and participation among team members, especially when they are geographically dispersed. However, there is a lack of

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practical, holistic frameworks to guide organizations in their efforts to select collaborative tools that can support their specific needs (Krenn & Stary, 2015; Weiseth et al., 2006).

De Vries and Opperman (2023) presented an initial summary of tool features that contribute to and encourage the process of a specific modeling context, i.e., for participative enterprise modeling (PEM). In their study, an iterative approach was used to experiment with two PEM tools, Miro (2025) and MURAL (2024), developing a comparative list of features. The purpose of their evaluation was to defend the selection of MURAL over Miro. To the best of our knowledge, there is currently no method or framework to sufficiently guide decision-makers in selecting a modeling tool that is appropriate and user-friendly within the specific context of PEM. Therefore, in this study, our primary objective is to systematically review literature and extract tool features that have contributed to PEM, addressing concerns regarding the rigor of the initial comparison matrix presented by De Vries and Opperman (2023). The primary research question is therefore: *Which specific tool features/functionality within particular contexts contribute to or present challenges in PEM?*

We apply a multivocal literature review (MLR), as defined by Garousi et al. (2019), i.e., a form of systematic literature review (SLR) which *also includes grey literature*. Although we follow a systematic process in searching the existing knowledge base, we do not have the intent to offer a standalone systematic literature review to provide an overview of an existing knowledge base, as is often the case with SLRs, according to Kraus et al. (2022). Our MLR could only be conducted by a single researcher, despite the traditional process required for an SLR, involving multiple researchers, which is time consuming (Carver et al., 2013; Okoli, 2015). As a *secondary* contribution of this study, we explored the use of AI as a research assistant to mitigate potential bias. We report on our experience, as only a few studies have explored the role of AI in this domain, despite the development of numerous tools to support SLRs (Bolaños et al., 2024).

This article is structured as follows. [Section 2](#) provides background on participative enterprise modeling and relevant literature. [Section 3](#) outlines the research method, beginning with the systematic review of literature conducted through the stages of planning, selection, extraction, and execution. [Section 4](#) presents the data and findings in relation to the research questions. During this stage, we identified a limitation of the initial review, i.e., some tools identified in our publications are no longer freely available, while other widely used modeling tools were excluded, partly due to the omission of grey literature. To address this limitation and capture a more comprehensive view of available tools, we extended the scope of our review to include grey literature, thereby evolving the study into an MLR. [Section 5](#) discusses the limitations and recommendations for further research and [Section 6](#) concludes with final remarks.

## 2. Background and related work

In this section, we introduce relevant literature and related work. This includes enterprise engineering ([Section 2.1](#)), participative enterprise modeling ([Section 2.2](#)), and tools that can be used for participative enterprise modeling ([Section 2.3](#)).

### 2.1. Enterprise engineering

The term “model” is used in various ways as highlighted by Dietz and Mulder (2024). In software engineering, the term “model” traditionally refers to an artifact formulated in a modeling language. An example is the Unified Modeling Language (UML), “describing a system through the help of various diagram types” (Kühne, 2004, p. 1). An *enterprise* model consists of a number of “sub-models,” each describing the enterprise from a particular perspective (Persson, 2000, p. 978). Dietz and Mulder (2024, p. 75) state that the only common denominator in the plethora of model notions is that a model is “a simplified representation of a thing, made for the purpose of studying those aspects of the thing that one is interested in.” While models can be used for simulation and deployment, their use often lies in sense-making, communication, and improvements within the organization (Krogstie, 2012).

Since this study focuses in particular on *enterprise* models, the discipline of enterprise engineering (EE) is used to provide context for defining enterprise models. The discipline of EE, which is multi-

disciplinary in nature (Giachetti, 2010), was founded in 2013 as a means to create scientific rigor in developing and testing theories within enterprises (Dietz et al., 2013; Dietz & Mulder, 2025). EE identifies alternative ways and initiatives to improve existing performance, often changing the design of multiple design domains (De Vries et al., 2015). The existing knowledge within EE can be represented through a common reference model known as the Enterprise Evolution Contextualization Model (EECM) (De Vries et al., 2017). Four enterprise design domains, developed via design science research (DSR), are presented by De Vries (2017):

- The Organization Domain, which incorporates relationships from interactions and communications when production acts are performed.
- The Information and Communication Technology (ICT) Domain, which incorporates software applications, databases and ICT hardware.
- The Infrastructure Domain, which entails facilities and other non-ICT technologies that support actor roles and their production acts.
- The Human Skills and Know-How Domain, which constitutes human abilities and skills required when executing production acts, as well as coordination acts.

Examples of models within the EE field could include cooperation models (CM) e.g., represented by the Coordination Structure Diagram (CSD) and Transaction Product Table (TPT) (Dietz & Mulder, 2024) in the *Organization* Domain, wireframing models (Garrett, 2011; Guilizzoni, 2025) in the *ICT* Domain, facilities layout models (Tompkins et al., 2010) in the *Infrastructure* Domain, and the National Qualifications Framework (NQF) (Walters et al., 2010) in the *Human Skills and Know-How* Domain Model. A Business Model Canvas (Osterwalder et al., 2010) is an example of a *Cross Domain* enterprise model, i.e., different domains as well as the *environmental* context applies.

## 2.2. Participative enterprise modeling

Enterprise modeling (EM), which emerged in the late 80's, is a central activity in EE (Vernadat, 2020). EM can be defined as “the art of externalizing knowledge in the form of models about the structure, functionality, behavior, organization, management, operations and maintenance of whole or part of an enterprise, or of an enterprise network, as well as the relationships with its environment” (Vernadat, 2020, p. 1) with Stirna and Persson (2018, p. 1) describing EM as “integrated and multi-perspective.” EM can be used to document the current or a desired future state of a company in a graphical and comprehensible way (Gutschmidt, 2021) and therefore often calls for *participation* of everyone involved (Gutschmidt et al., 2019). Participative enterprise modeling (PEM) is defined as “an activity where an integrated and negotiated model of an enterprise is created using a participative way of working” (Persson, 2000). Gutschmidt (2021) describes PEM as a “fruitful method of eliciting information and creating enterprise models at the same time” where stakeholders actively engage by discussing and drawing the model themselves, resulting in several benefits (Gutschmidt et al., 2025; Sandkuhl & Seigerroth, 2020).

The main goal of *collaborative* modeling is to attain complete models in a fast and accurate way (Barjis, 2009) whereas *participatory* modeling (PM) is characterized by involving stakeholders as domain experts directly and actively in the modeling process (Gutschmidt, 2021). Sandkuhl and Seigerroth (2020, p. 3) differentiate between conventional EM and PEM through the number of modelers and stakeholders involved in the creation of the models, with PEM actively involving relevant stakeholders in the modeling session “both to provide domain knowledge and to participate in the creation of models (modeling) in a collaborative way.”

## 2.3. Tools for participative enterprise modeling

Various tools exist that support various modeling methods. According to Stirna and Persson (2018), there are two main *types* of tools for PEM: (1) The plastic wall and (2) A projector and a computerized tool. Their use depends on the type of model and session, e.g., the plastic wall is more suitable when

idea generation is the primary focus or when the group is large. Stirna and Persson (2018) caution against the use of a computerized tool. They argue that these tools often divert the group's focus to non-modeling actions like file management and technical issues, and that the available solutions and technologies are not well-suited for multi-user interaction. However, as technology continues to evolve, these concerns are being addressed.

There are tools that allow users to present and capture information, like Miro, MURAL, and ConceptBoard (de Andrade et al., 2024). Jackson et al. (2022) refer to this type of technology as *artifact management*. They differentiate between different types of artifact management, e.g., virtual whiteboard software as “an online space for multiple participants to collaboratively create and edit content” whereas diagramming refers to software “to produce and share diagrams online” (Jackson et al., 2022, p. 6). According to Gutschmidt (2021), distributed collaborative modeling tools may be divided into those that work asynchronously and those that work synchronously, with synchronous approaches promising a reduction of inconsistency and versioning issues. Weiseth et al. (2006, p. 240) define collaboration tools as a “specific combination of a collaboration interface, collaboration functions, and content management and process integration functions.” Another term seen in literature is groupware, which is a type of multi-user computer technology that supports people during the process of collaboration (Gallardo et al., 2011; Geszten et al., 2024).

Usability plays an important role in these tools, as interactive systems should enable users to achieve their goals with effectiveness, efficiency, and satisfaction (Andrés et al., 2016). Evaluations of these collaborative tools are often based on their usability and their effectiveness (Fleche et al., 2014) with several studies exploring different aspects of tool selection and evaluation, such as the *selection* of modeling tools (Walterbusch et al., 2013), the *classification* of tools for specific contexts (Riemer et al., 2011; Szopinski et al., 2017), listing required features from literature (Gutschmidt et al., 2019; Maranzana et al., 2020), and comparing different tools using usability scales like satisfaction and usability scores (Gallardo et al., 2011; Rittgen, 2009; Ssebugwawo et al., 2013).

### 3. Research method

In this section, we start by motivating the use of an MLR (Section 3.1) and then explicitly state when and how AI was used during the review process (Section 3.2). The steps followed are then detailed according to the main phases of the process, i.e., planning (Section 3.3), selection (Section 3.4), extraction (Section 3.5), and execution (Section 3.6).

#### 3.1. Review type

The aim of an SLR is to “identify and retrieve international evidence that is relevant to a particular question or questions and to appraise and synthesize the results of this search to inform practice, policy and in some cases, further research” (Munn et al., 2018, p. 2). An MLR is a “form of a Systematic Literature Review (SLR) which includes the grey literature (e.g., blog posts and white papers) in addition to the published (formal) literature (e.g., journal and conference papers)” (Garousi et al., 2019, p. 101). MLRs are used to provide summaries, both from the state-of-the art, and practice-based knowledge. Since the MLR still obtains knowledge from academic sources, SLR guidelines are still useful.

The SLR part of our MLR is an appropriate research strategy due to the following considerations: (1) A number of reviews exist focusing on the selection of modeling tools and/or the classification of tools and relevant features, but not related to our context of PEM, (2) Usability and EM research is a well-established field, and (3) We have specific questions related to this field that we want to investigate. Okoli (2015) also introduces a standardized methodology for the SLR to enhance the quality of research in information systems (IS) which this study adopts. The steps are classified into different phases, i.e., Planning, Selection, Extraction, and Execution. Page et al. (2021) also suggest that researchers use a PRISMA 2020 checklist as guideline for reporting on systematic reviews. Although we did not apply all of the checklist items, since PRISMA 2020 “has been designed primarily for systematic reviews of studies that evaluate the effects of health interventions” (Page et al., 2021, p. 2), items were useful to discuss some possible limitations of our study.

**Table 1.** Secondary research questions.

ID	Research question
1	What type(s) of enterprise models were created in the studies?
2	Which tool(s) <sup>a</sup> were evaluated within the context of PEM?
3	Who were the study participants, and were they co-located or remote during participation?
4	What was the purpose of each evaluation, and what methods were used to evaluate the tools?

<sup>a</sup>Tools refer to online platforms or applications used to support PEM. It does not refer to conceptual methods or frameworks.

The grey literature part of our SLR is appropriate since the academic literature was incomplete as a knowledge base for extracting tool features. Due to the gap identified in the academic literature, we had to extract knowledge from existing tools, as presented in grey literature, to answer the main research question. The grey literature review is presented in [Section 4.4](#).

### 3.2. AI assistance

According to Bernard et al. (2025), the use of an AI tool should only be at certain stages of the systematic review process, and for transparency and reproducibility, it is crucial to mention the use of AI tools in the methodology section. AI was used to *complement*, or support, the process of systematically reviewing the literature across all its phases. We detail the tools used and how they were used per SLR phase in [Supplementary Appendix A](#). More detail on the researcher's experience using these tools is also detailed in the subsequent sections.

### 3.3. Planning

The first step, according to Okoli (2015), is to identify the *purpose* of the SLR. We wanted to (1) Determine which other studies have already provided an overview of tool features/functionality that contribute to PEM, and (2) Extract these tool features (and problems associated to these features) to enhance the initial features identified by De Vries and Opperman (2023).

The primary research question is repeated: *Which specific tool features/functionality within particular contexts contribute to or present challenges in PEM?* We also extracted some contextual information (e.g., publication year) to answer the secondary research questions ([Table 1](#)), which were identified and formulated to meet the scope and objectives of the study.

Once the research questions were formulated, the research protocol served as the road map toward the answers (i.e., the *second* step). With regards to the *training of the team*, even though it is impractical for one person to comb through the entire literature single-handedly (Okoli, 2015), due to resource limitations and the growing potential of AI tools as research assistants, our literature review was conducted by one experienced researcher. This researcher has conducted a traditional SLR before and understood the requirements for a standalone SLR.

### 3.4. Selection

In the *third* step, the reviewers must explicitly decide on and explain the criteria for selecting or excluding papers from the review (Okoli, 2015). The following inclusion/exclusion criteria were identified:

- **Content (topics or variables):**
  - Initially, only literature with titles that indicate that the content of the literature is relevant to the research question(s) were included. This was done to ensure that studies extracted are aligned with our inquiry, and to reduce the number of studies during full-text reading. If the researcher was unsure of the content, based on reading the title, the keywords and/or abstract of the article was also read. The article was therefore not excluded when there was uncertainty in the practical screening.
  - Since *collaboration* and *modeling* are often vaguely defined and interpreted differently across studies, we did not restrict our search terms/selected studies to PEM. Instead, we focused on evaluating each article for its relevance to our research objectives. For instance, if stakeholders

- collaboratively created a model in a synchronous way (whether remote or co-located) using an online tool, the article was considered for inclusion in our review, even if it did not explicitly use the terms “Participative Enterprise Modeling” or “Enterprise Model.”
- Documents that focused solely on collaborative decision-making were excluded, e.g., Jin et al. (2017) developed a collaborative visual analytics tool to support healthcare professionals in making decisions about appropriate antibiotic prescriptions and Militello et al. (2008) developed a tool to support collaborative decision-making via visualizations. Such studies, while involving collaboration, did not align with our criteria as articles needed to include participants that work together *within* a tool to jointly create or modify a model. Thus, “collaborative” in our context refers not only to the *process of selection* or decision-making, but to the collaborative nature of the tasks conducted within the tool itself.
  - Studies were only included if they contained some sort of evaluation and extraction of tool features. For example, studies that only compared tools based on their usability score/a scale were excluded, as we focused on identifying *specific* features that contribute to the scores/findings.
  - **Publication language and publication availability:**
    - Only studies written in English, where full text could be accessed either online by the researcher or via an inter-library loan (within a specific time frame) were included. Some relevant studies identified by title/abstract were excluded due to being published in another language, for example studies by Silva et al. (2022) and Emmanuel Savio Silva et al. (2018) were only published in Portuguese and were therefore excluded.
    - Publication types included journal articles, conference articles and book chapters. Books were excluded from the review.
  - **Publication length:** Only studies consisting of five or more pages were included as we assume that studies consisting of less than five pages will not be comprehensive enough to provide insights into the evaluation.
  - **Peer-review status:** Aligned with our motivation to use an MLR, studies were included regardless of the peer-review status. We made this decision as we were not expecting to find many relevant peer reviewed articles based on an initial search and did not want to unnecessarily exclude relevant articles.
  - **Date of publication:** Sources were included regardless of publication date i.e., all sources published/available up to April 2025 were included, ensuring that all relevant articles were analyzed.

The *fourth* step in conducting an SLR involves searching the literature (Okoli, 2015). A database search strategy is the most common and the first published recommendation for SLRs in the software engineering (SE) domain (Keele, 2007). For this study, we therefore decided to conduct searches across four leading scientific digital library databases relevant to the field of ICT, as indicated in Table 2 (University of Kentucky, 2025; University of Pretoria, 2025; University of Tasmania, 2024). IEEE (2025) is also a leading and relevant database but was excluded in the initial search due to timeout issues experienced at the time of the review. These searches were also supplemented with the readily available AI tools SciSpace (PubGenius Inc., 2025) and Elicit (2025). SciSpace and Elicit were selected as we did not want to develop custom AI solutions, but rather utilize relatively established, accessible platforms to assist in the review. The initial results and the number of studies remaining after title screening are summarized in Table 2.

**Table 2.** Overview of studies identified per source.

Database	Initial results	Nr. of studies after <i>title*</i> screen
Web of Science (WOS) Core Collection	1,887	45
Scopus	735	66
ACM Digital Library	143	7
Springer Nature Link	69	8
SciSpace		12
Elicit		4
Other		1
Total	2,528	143

**Table 3.** Search string used for our study.

Rationale	Search strategies
Study should describe the evaluation and/or selection of online modeling tools	ti:(“decision-making” OR compar* OR deci* OR analys* OR choos* OR choice OR chos* OR select* OR identif* OR determin* OR evaluat*)
Study should include collaborative or participatory elements	ti:(collaborat* OR “participative” OR “participatory” OR co-creat* OR “whiteboard” OR “workspace” OR “modeling” OR “modeling”)
Study should focus on online tools/software	ti:(“software” OR “tool”)

For the traditional screening, an automated search was executed on the digital libraries using the keywords included in Table 3. Synonyms for relative terms were identified by reviewing related work. Wildcards (“\*”) were also used to accommodate grammatical variants of a base word.

As beforementioned, the SLR was conducted by a single researcher which is acknowledged as a potential threat to validity. However, to mitigate this risk and address the concerns of single-researcher bias, we incorporated AI as a “team member.” Specifically, we experimented with ChatGPT 4o (OpenAI, 2023) to assess the relevance of articles identified in our search. This AI tool served as an “independent screener” to validate the initial manual screening decisions made by the researcher. For the search in Springer Link, for example, the researcher first conducted a manual review of 69 article titles, identifying 4 as relevant. This initial selection was then cross-validated using ChatGPT, which independently identified 2 of the 4 researcher-selected articles and proposed 7 additional articles. Subsequent manual verification of these new articles confirmed that 3 were indeed relevant.

ChatGPT’s ability to identify additional relevant articles that were initially missed by the researcher demonstrates its value in mitigating single-researcher oversight. While AI tools were not used for all databases (ACM and WOS were only screened manually), the successful application of this methodology provides an example of how AI was strategically employed as a validity safeguard.

### 3.5. Extraction

Data is extracted in the *fifth* step, and the quality is appraised in the *sixth* step. In our literature review, we first evaluated the quality of the articles before extracting the data, as we did not want to go through the effort of extracting data from articles that did not adhere to our quality requirements. Relevance was assessed by screening each study to determine its alignment with the primary and secondary research questions. This process involved both AI-assisted and manual approaches. SciSpace was used to pose specific questions to the PDF, generate summary tables indicating whether key content was present, and provide brief overviews of each article. Additionally, all articles were manually screened by the researcher.

To be included, studies had to involve some form of modeling, incorporate participation (i.e., teams of at least two people working together), and feature an “online” element (such as the use of a software application or platform). We excluded studies focused primarily on virtual reality (VR)-based modeling. This is to ensure comparability and generalizability of findings, as VR introduces unique interaction mechanisms and user experiences that differ from more conventional collaborative modeling tools.

After compiling our initial list of studies, we applied both forward and backward snowballing to identify additional relevant literature. Snowballing is a viable alternative or complementary addition to the database search strategy, as using either database searches or snowballing *alone* may be insufficient to achieve high-quality results (Mourão et al., 2020). We used ResearchRabbit (Research Rabbit, 2025) and Google Scholar for the forward and backward snowballing process.

The new studies identified through snowballing were then screened, applying the same selection techniques included in the previous section, i.e., the selection process was repeated. Once the backward and forward snowballing was done for one iteration, the newly identified and accepted studies were reserved for the next iteration. To ensure traceability, one iteration was performed at a time and a Microsoft (MS) Excel spreadsheet was used to track which studies were identified during a particular round of snowballing. The process was stopped once data saturation was achieved, i.e., no additional papers were identified during a snowballing iteration. An extract from the MS Excel sheet in which we tracked the process is included in Figure 1.

Database	Title	Detail	Similar	NewTitles	B5/FS	Comment	able to download/find
SciSpace	Applying AHP for Collaborative Modeling Evaluation: Experiences from a Modeling Experiment	RR	Yes	An exploratory study of IT enabled collaborative process modeling	SW		Yes
SciSpace	Applying AHP for Collaborative Modeling Evaluation: Experiences from a Modeling Experiment	RR	Yes	Evaluating Participatory Modeling: Developing a Framework for Cross-Care Analysis		Already excluded	
Scopus	Collaborative design tools in engineering education: insight to choose the appropriate PLM software	RR	Yes				
SciSpace	Collaborative process modelling - tool analysis and design implications	Manual	No	Modeling with a group modeling tool: group support, model quality, and validation	B5		Yes
SciSpace	Collaborative process modelling - tool analysis and design implications	Manual	No	Facilitation methods for collaborative modeling tools	B5		Yes
SciSpace	Collaborative process modelling - tool analysis and design implications	Manual	No	Supporting multiple viewpoints in collaborative graphical editing	B5		Yes
SciSpace	Collaborative process modelling - tool analysis and design implications	Manual	No	Tools for collaborative Business Process Modeling: Classification and Evaluation	B5	Could not obtain full	article

Figure 1. An extract from the MS Excel sheet in which the selection process was managed.

Type	Journal Related					Article Related			Decision	Comment		
	Predatory Jol	IF	Rar	DHET at	DOAJ Removed	Publisher	Retract	WOS Lit			Scopus	Peer review
Journal	No	Could not find	N.A.	Y	N	Akademik-Bilim-Arastirmalar Dernegi/SocSci	N	N	N	Peer-review	Exclude	
Conference	N.A.	N.A.	N.A.	N.A.	N.A.	AIS Electronic Library	N	N	N	Double-blind review	Include	Author is well known in the field
Conference	N.A.	N.A.	N.A.	Y	N.A.	SpringerNature	N	Y	Y	Peer reviewed	Include	
Journal	No	0.8	N.A.	Y	N	igi-global	N	N	Y	Double-anonymized-peer-review	Exclude	Presents a framework for decision making.

Figure 2. An extract showing how the validity and relevance of articles was tracked.

Of the studies screened, 29 were included in a list for further validation. A table was manually compiled to evaluate the quality of both the journals and the articles. Our quality assessment primarily focused on verifying source credibility. For journal articles, we checked whether the journal appeared on a list of predatory journals (Retraction Watch, 2025) at the beginning of May 2025, considered the journal's impact factor, and confirmed inclusion on our University's accredited journal list. For all articles, we confirmed the publisher, confirmed whether the article was peer-reviewed and determined whether the article could be found on either WOS or Scopus. An extract from this table is included in Figure 2.

Three articles were excluded as they were not available in either WOS or Scopus. However, one article which could not be found in either database was *included* due to the author's established reputation in the PEM field. In addition to this, four articles were excluded during full-text reading as we realized they were either duplicate studies or studies which had an updated version of the research published. In these cases, only the more recent version of the study was included. A few more articles were excluded after full review as it became clear that they only partially addressed our research question.

A summary of the overall process is included in Figure 3. The initial 143 articles were reduced to 13 selected *primary publications* (PP) listed in Supplementary Appendix B.

The research questions inspired data extraction. The information was summarized and organized into a table by SciSpace, based on prompts provided. The table was downloaded to MS Excel, after which the researcher read through the articles, verifying, i.e., updating/deleting where necessary, the data extracted by SciSpace. At this stage, the researcher upgraded to a paid version of SciSpace to be able to download the full table and interact with more PDF documents.

To enhance the rigor and efficiency of our data extraction process, ChatGPT was used as a research assistant and sanity check. To analyze and extract the *feature(s)* from each study, we experimented with prompt engineering, basing our initial prompts on an approach proposed by Naeem et al. (2025). The primary researcher provided ChatGPT with the initial list of features and the primary publications to extract themes and supporting quotes aligned to the list. The researcher therefore compared their findings to cross-check interpretations and ensure no relevant features were missed. The primary researcher always read each article, making the process of validation and refinement transparent through visual tracking. As shown in Figure 4, changes recommended by ChatGPT were highlighted in blue, while blue sections that were struck through (e.g., ~~like this~~) represent suggestions reviewed and rejected by the researcher. Changes made in orange were added by the researcher.

Changes were iteratively made to the feature repository, extracting supporting quotes per article (as shown in Figure 5). The article by De Vries and Opperman (2023) was not reviewed, as they developed the initial list that we used to expand on.

After completing the initial review of the articles and extracting features from each one, we began refining the feature repository by iteratively updating and reorganizing the categories. To track these changes, we used separate tabs in MS Excel. The updated list of features resulting from this process is discussed in Section 4.3.

It should be noted that the final repository contents reflect the human researcher's interpretation and decisions. The AI tool's role was strictly to augment the process, not to replace human judgment. After observing that ChatGPT sometimes hallucinated quotes or extracted features from the initial list of features provided for reference, the extraction from the final four articles was reverted to manual-only extraction.

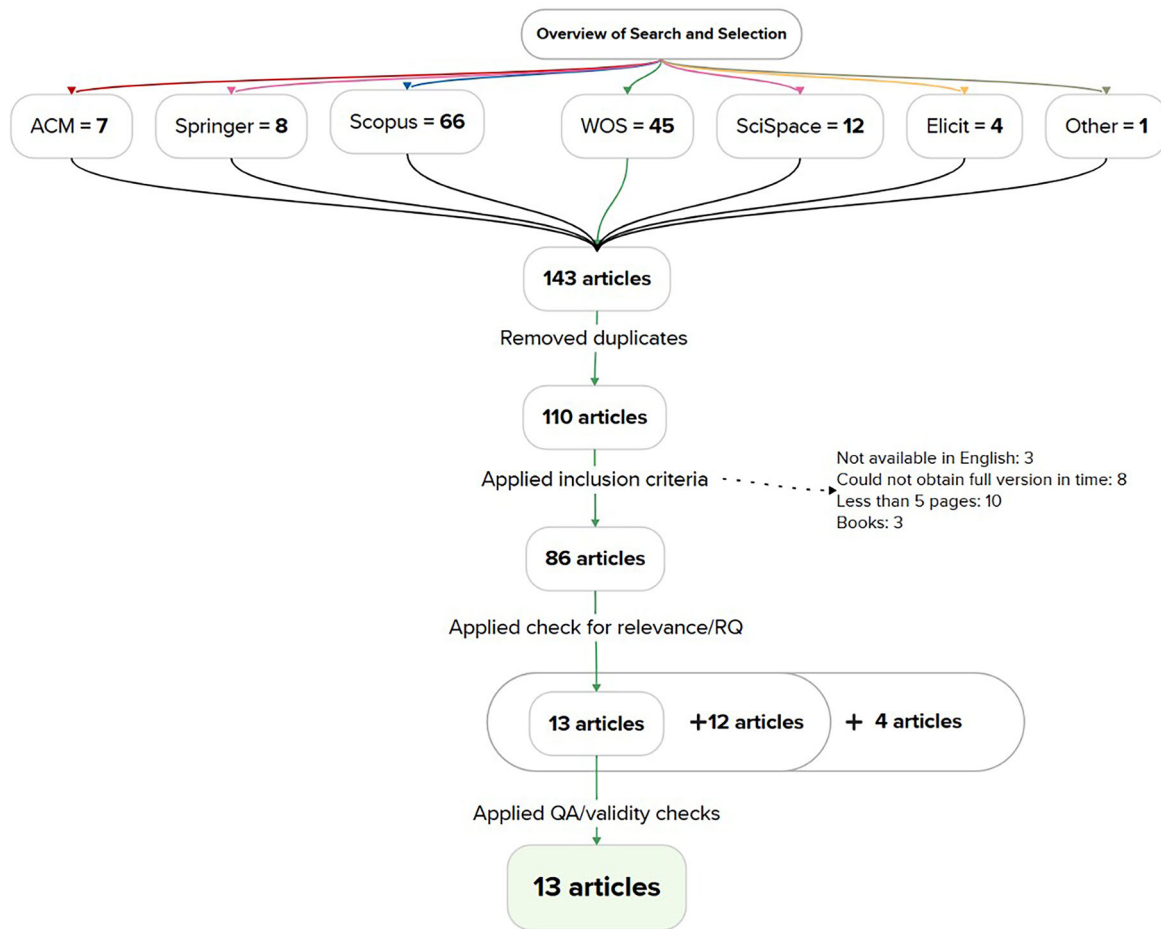


Figure 3. An overview of the selection process.

Feature	PEM Requirement	Supporting quotes
<b>Participation enablers</b>		
Interactive modelling	There should not be any latency in reflecting updates performed by multiple Users should be able to communicate verbally while they produce diagrams. An integrated feature is not an entry requirements, since it is also possible to use the tool in combination with other platforms such as Zoom and Google Meet.	
Integrated voice-chat function		"Not being able to record the session and communicate with the co-modeller within MURAL itself."
Communication integration	Should have in-platform audio or video chat to enhance synchronicity	"The zoom function makes it very hard to locate where your co-modeller is working on the"
Collaboration Awareness	Should show cursor position, co-modeller identity, and activity in real time	"There were cases when drawing connection arrows that MURAL would freeze..."
Platform Stability	Should handle concurrent users without lag or crashes	
<b>Privileges for using the tool</b>		
Workspace membership control	Full members should be prevented from adding new members if membership numbers are restricted. During the main experiment, the administrators need to ensure that participants of the experiment have "full member" privileges.	
Workspace privilege control	Administrators should have control over workspace privileges, e.g. preventing members from adding new rooms. The experiment requires monitoring of activity within the rooms and therefore rooms had to be created by the administrators.	
Board membership control	Should provide board membership to selected members (i.e, all participants in the SCM experiment).	
Board access control	Should be able to manage the users (members and visitors) per board, also removing users from a board.	
Board access control relating to new memberships	Should allow Education members to invite visitors from outside with "edit" abilities on a board without occupying full memberships.	
User type access for board access	Users that are invited to a board should also allow access to "industry" users with editing access.	
<b>Exporting</b>		
Exporting to .csv	Should facilitate exporting of a table to a .csv file.	
Exporting diagram to .png or .pdf	Should facilitate exporting of diagrams to .png or .pdf. Should maintain clarity and legibility at high zoom levels	"Details would not be sufficiently visible in the PNG image."
<b>Ease of modelling</b>		
User interface intuitiveness	Should have an intuitive user-interface in terms of the layout of modelling options, zooming in and out, "undo" a change with a button. Navigation should be easy to learn	"No descriptions or tooltips when hovering over icons."
Construct editing control	Should be able to group constructs into areas to lock/unlock areas for participating users, indicating its locked status.	
Moving and re-sizing a construct within a "group"	Should be able to easily move/re-size a single construct within a group. It should be possible to increase the size of a construct that forms part of a group to ensure that the embedded text is readable.	"Formatting the fonts elements, no auto sizing feature, so one had to make sure it's properly done, causing a lot of moving objects along the"
Tool tip	Should have a tool tip for contextual help	"No descriptions or tooltips when hovering over icons" "Sticky notes were accidentally created more"

Figure 4. Extract of feature extraction process.

Feature	PEM Requirement	Supporting quotes			
		Usability of virtual tools for participatory enterprise modelling	An exploratory comparison of tools for remote collaborative and participatory enterprise modeling	An Exploratory Study of IT-Enabled Collaborative Process Modeling	Evaluating the Usability of Online Tools During Participatory Enterprise Modelling, Using the Business Model Canvas
<i>Participation enablers</i>					
Interactive modelling	There should not be any latency in reflecting updates performed by multiple participants.	"There were cases when drawing connection arrows that MURAL would freeze..."	liked that you could work together in one model and see what the others were doing in real-time. "Every user should be able to interact with the software, ideally at the same time", "were interfering with each other, probably due to a time delay in their interactions with the model"	"Latency, Errors (e.g. steady reloading) ([...] can't scroll[...]), [...] system keeps reload all the time"; observed in both cases"	"There should not be any latency in reflecting updates performed by multiple participants.", "It sometimes froze when I was zooming", "Since everyone was supposed to work on MURAL together – at once – it was difficult because so many changes were being made at the same time.", "Auto-refresh problems... work had been lost as a result of this.", "Having a few members working on Mural simultaneously causes the program to glitch, and not always save the alterations made"
Integration or compatibility with video/voice platforms	Users should be able to communicate verbally while they produce diagrams (should support synchronous communication). An integrated feature is not an entry requirements, since it is also possible to use the tool in combination with other platforms such as Zoom and Google Meet.		Zoom allowed voice communication, but nonverbal cues were missing, provide the participants with a video conference system to allow synchronous voice communication and visual contact. Based on our experience at our university, we chose Zoom as the most reliable tool.	"[...] would probably work better with some kind of voice support[...]" "The modeling tool provided chatting but not VoIP functionality albeit, admittedly, such functionality could have been used through other software (e.g., Skype)"	"Users should be able to communicate verbally while they produce diagrams."

Figure 5. Extract indicating how different quotes were extracted per feature per article.

### 3.6. Execution

The *seventh* step is synthesizing the studies, which can then be used in the *eighth* step, i.e., writing the review. As mentioned in Section 1, aligned with the primary research question, we provide an overview of tool features within specific contexts of literature that contributed to and/or provided challenges to PEM.

## 4. Results and discussions

We provide an overview of other literature reviews identified in Section 4.1. The contexts of the thirteen primary publications (PP) are summarized in Section 4.2. In this sub-section, we calculate the frequency as the unique number of studies that referred to a particular theme and provide a summary of the studies, where required. An updated feature repository of extracted features, from literature, is presented in Section 4.3.

### 4.1. Related work

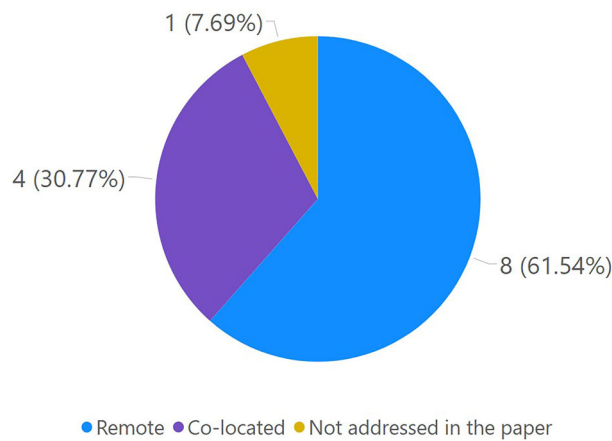
We found no other literature reviews that provide a summary of tool features or functionalities specifically within PEM. Riemer et al. (2011) analyzed and classified *process modeling* tools with regards to their collaborative features for supporting the modeling task. They identified three categories/dimensions (process modeling criteria, collaboration criteria, and technical criteria), with each of these containing a list of features. Bafoutsou and Mentzas (2002) present a *collaborative application taxonomy*, using literature to classify tools in the domain of collaborative computing. They classified tools, referred to as *products* in their study, according to more than 25 features.

### 4.2. Summary of primary publications

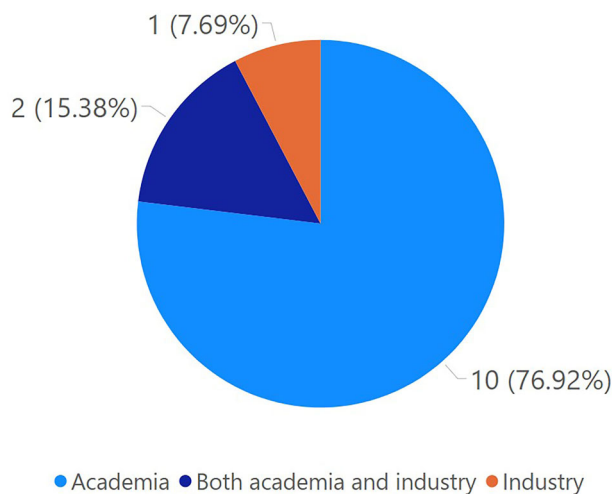
Thirteen PP, detailed in Supplementary Appendix B, were analyzed. The *earliest* relevant study was published in 1996. The years with the highest number of studies were 2019, 2023, and 2024, with two studies published in each of those years. Marné de Vries contributed to the most studies (three of the thirteen), while Dalma Geszten, Anne Gutschmidt, Anthea Venter and Károly Hercegfí each contributed two.

Most of the tools identified from these PP were used to create models in the *Organization* Domain (refer to Section 2). Based on the information summarized in Supplementary Appendix C, most studies focused on *remote* modeling (refer to Figure 6) and most evaluations took place within an *academic* environment, i.e., most studies included students as participants (refer to Figure 7).

Most evaluations consisted of paired participants (refer to Figure 8). More information on the participants per study is included in Supplementary Appendix C.



**Figure 6.** Type of modeling.



**Figure 7.** Context of evaluation.

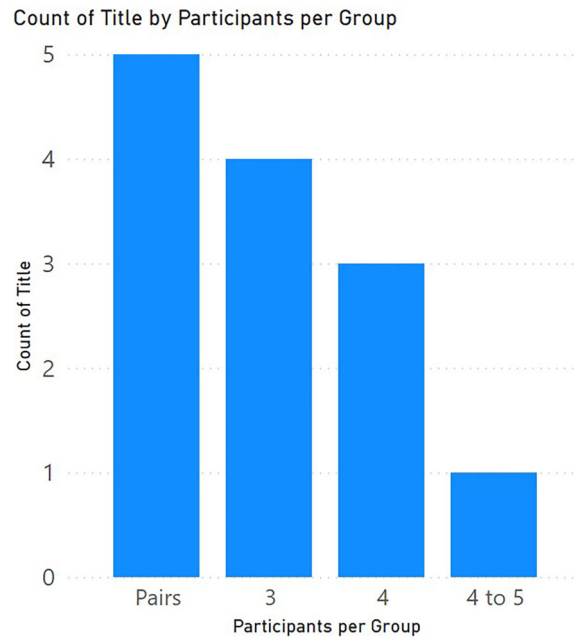
An overview of the purpose of the evaluation per study as well as the process followed to evaluate the tools is included in [Supplementary Appendix D](#). While questionnaires and surveys are the most common evaluation methods (mentioned in 8 out of the 13 studies), many studies adopted a multi-faceted approach. Researchers often triangulate findings through mixed-methods, such as analyzing chat logs to identify user difficulties or using expert heuristic evaluations to validate user feedback. Most evaluations focused on assessing the usability and user experience of tools whereas some focused on evaluating the effectiveness of the modeling and collaboration process itself. This involved analyzing outcomes like the quality of diagrams and solutions (Aytes, 1994; De Vries & Opperman, 2023) or studying collaborative dynamics such as communication breakdowns (Hahn et al., 2011) and participation levels (Aytes, 1994; De Vries & Opperman, 2023).

Thirteen tools were evaluated with most studies (three) evaluating MURAL as shown in [Figure 9](#).

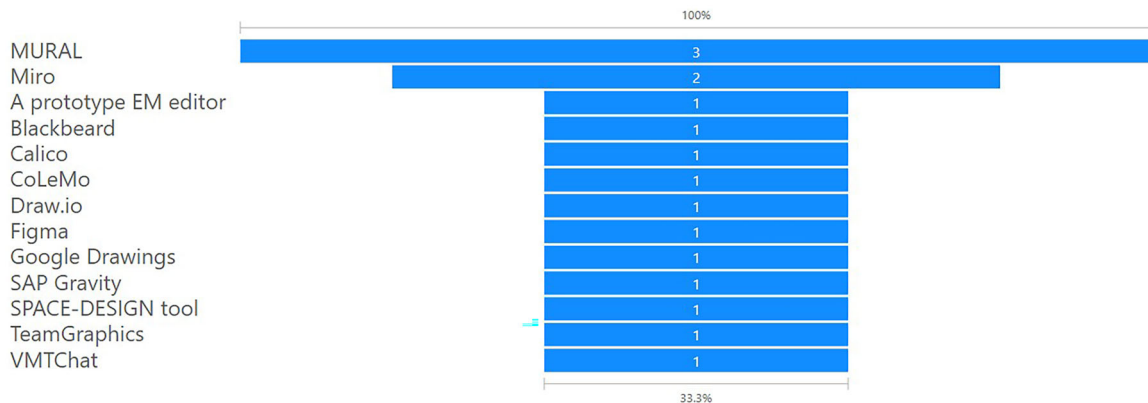
Since 2023, the tools Miro and MURAL have been the primary focus of evaluations. Other recent tools examined include a prototype enterprise modeling editor developed at the University of Rostock (Gutschmidt et al., 2019), Draw.io (JGraph Ltd, 2023), FigJam (2025), and Google Drawings (Buggs, 2025) as shown in [Figure 10](#).

#### **4.3. Updating the feature repository using academic literature**

All of the PP extracted and/or discussed features that contributed to PEM. These features were used to refine the previous work done, developing a *repository* of features. [Figure 11](#) presents a high-level overview of the categories within our repository. Each category, such as participation enablers, branches out



**Figure 8.** Number of participants in the groups.



**Figure 9.** Tools evaluated in the studies.

into more detailed, sub-categories of features. For illustration, [Figure 11](#) indicates how the *participation enablers* category was expanded into sub-features, i.e., interactive modeling, real-time communication support, collaboration awareness, device compatibility and facilitator enablement. The arrows, i.e., “>,” shown in [Figure 11](#), indicate that some of the sub-features can be further expanded.

This repository extends the existing classifications included in [Section 4.1](#) by providing more granular definitions and modernizing features. For example, similar to the concept of “synchronous work on documents/slides” from Bafoutsou and Mentzas (2002) and “concurrent modeling”/“synchronous modeling” from Riemer et al. (2011), our repository includes a refined feature that explicitly requires real-time updates with no latency. Another example is where we enhanced the general notion of “workspace awareness” by Riemer et al. (2011), decomposing it into specific subcategories. We define this feature with detailed requirements, such as displaying real-time cursor position, co-modeller identity and activity, as well as including a visual representation of users within the shared workspace. We also update earlier work by incorporating features that were not necessarily relevant at the time. For example, instead of just mentioning “computer conferencing” we distinguish between different communication types, such as in-platform audio, video, chat, and notes/comments. This distinction reflects the evolution of modern collaborative tools.

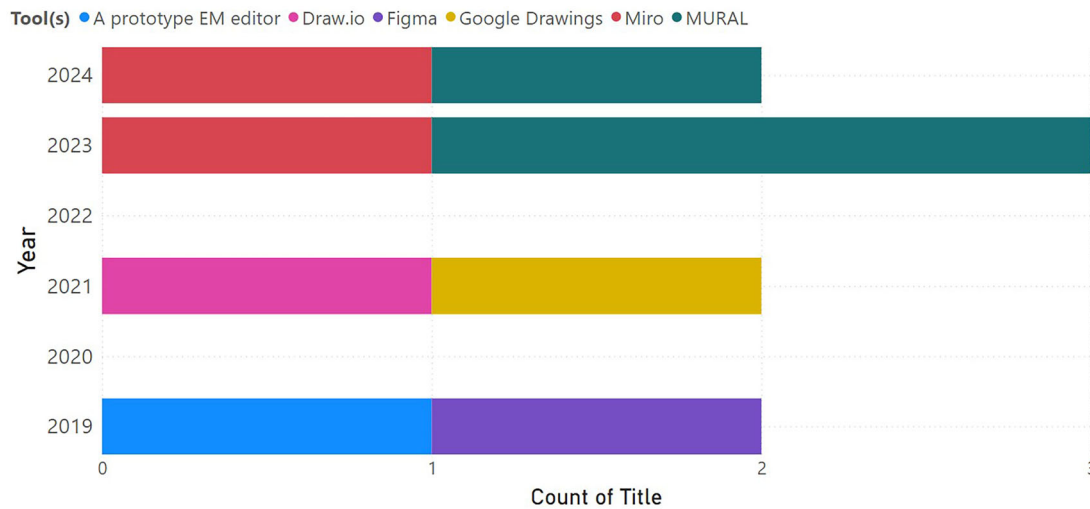


Figure 10. Tools evaluated in the studies per year, since 2019.

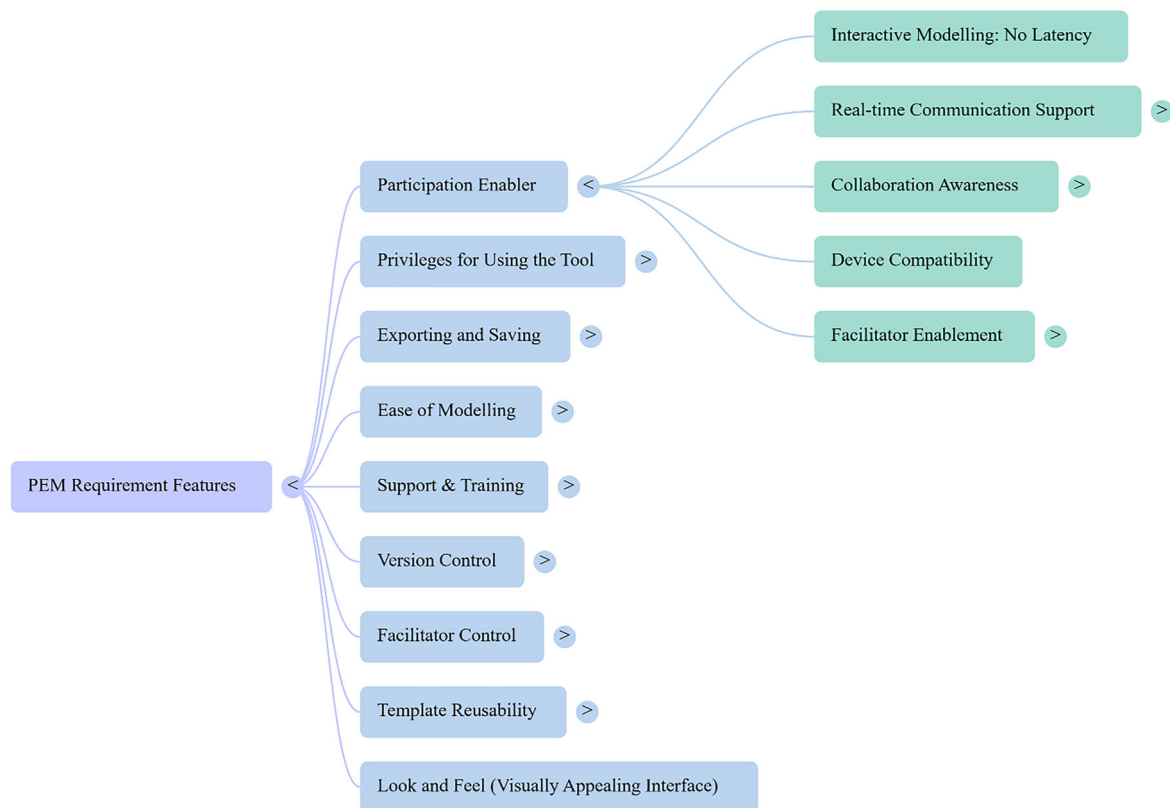


Figure 11. Overview of the repository with some sections expanded for context.

Table 4 indicates the feature(s) extracted from academic literature, included per publication. A more detailed version of the PP-based repository, including some supporting quotes extracted from each publication, is provided [here](#). The numbering of the studies corresponds with the publication summary provided in [Supplementary Appendix B](#). The repository presented in Table 4 and in the provided link reflects the version prior to validation, while the updated version, following validation (refer to [Section 4.5](#)), is included in [Supplementary Appendix E](#).

The category least represented by PP in the repository is *privileges for using the tool*. These features were originally added from the researchers' perspective in De Vries and Opperman (2023). The primary

Table 4. Features found in each of the thirteen primary publications.

Feature	1	2	3	4	5	6	7	8	9	10	11	12	13
PEM requirement													
<i>Participation enabler</i>													
Interactive modeling	X	X	X	X	X	X	X	X				X	X
Real-time communication support	X	X		X	X	X			X				
	There <b>should</b> not be any latency in reflecting updates performed by multiple participants. Users <b>should</b> be able to communicate verbally while they produce diagrams (should support synchronous communication). An integrated feature is <b>not</b> an entry requirement, since it is also possible to use the tool in combination with other platforms such as Zoom and Google Meet.												
	<b>Should</b> have in-platform audio, video, chat to enhance synchronicity												
	<b>Should</b> show cursor position, co-modeller identity, and activity in real time												
	<b>Should</b> include a representation of users (i.e., an avatar) in the shared workspace												
	<b>Should</b> be compatible with ...												
	<b>Should</b> provide functionality to support facilitators in coordinating group activities and ensuring effective collaboration, e.g., mechanisms for encouraging engagement (e.g., prompting inactive users), notifying participants of key events (such as new members joining), and supporting turn-taking and agreement-building during sessions.												
	Full members <b>should</b> be prevented from adding new members if membership numbers are restricted. During the main experiment, the administrators need to ensure that participants of the experiment have "full member" privileges.												
	Administrators <b>should have</b> control over workspace privileges, e.g., preventing members from adding new rooms. The experiment requires monitoring of activity within the rooms and therefore rooms had to be created by the administrators.												
	<b>Should</b> provide board membership to selected members (i.e, all participants in the SCM experiment).												
	<b>Should</b> be able to manage the users (members and visitors) per board, also removing users from a board.												
	<b>Should</b> allow Education members to invite visitors from outside with "edit" abilities on a board without occupying full memberships.												
	Users that are invited to a board <b>should</b> also allow access to "industry" users with editing access.												
	<b>Should</b> facilitate exporting of a table to a .csv file.												
<i>Privileges for using the tool</i>													
Workspace membership control													
Workspace privilege control													
Board membership control													
Board access control													
Board access control relating to new memberships												X	
User type access for board access													
Exporting and saving													
Exporting to .csv													
Exporting diagram to .png											X		X

(continued)

Table 4. Continued.

Feature	1	2	3	4	5	6	7	8	9	10	11	12	13
	PEM requirement												
Exporting diagram to pdf	<b>Should</b> facilitate exporting of diagrams to .png. <b>Should</b> maintain clarity and legibility at high zoom levels												
(Auto)save and model loading								X			X		
Re-use diagrams between different modeling platforms	<b>Should</b> facilitate exporting of diagrams to .pdf. <b>Should</b> maintain clarity and legibility at high zoom levels												
Ease of modeling													
User interface intuitiveness													
Handling of large models/sufficient modeling space													
Construct editing control													
Moving and re-sizing a construct within a "group"													
Arrow management													
Referencing to other drawings/constructs													
Gesture-based input													
Support and training													
Response time													
Self-training													

(continued)



researcher of this study also highlights the importance of these features, as they are often responsible for setting up the workspaces, e.g., ensuring only students enrolled in the module have access to the board. A possible reason for under-representation of some features, is that issues related to permissions and privileges did not emerge during the experiments and were addressed before designers started with evaluation.

The repository (included in [Supplementary Appendix E](#)) includes features relevant to the context of PEM, based on the features extracted from the thirteen PP as well as the features initially provided by De Vries and Opperman (2023) for comparison. In the repository, changes made in *orange* were added by the researcher and the sections in *green* indicate the original list of features. The *purple* changes highlight amendments based on features, identified from grey literature, as detailed in the next section ([Section 4.4](#)). This approach was used to clearly distinguish between features derived from academic literature and those originating from less formal, yet valuable, sources.

#### 4.4. Updating the feature repository using grey literature

The focus of our study was to determine which important tool features have been identified during PEM. We extracted features from *academic* literature for rigor and credibility, and used these to update the comparison matrix originally presented by Opperman and de Vries (2022). However, some of the tools identified in our PP are no longer freely available, and other widely used modeling tools exist, but were not extracted from our SLR. This could partly be due to the exclusion of grey literature. For instance, the recent study by Geszten et al. (2024) indicates that participants had collaborative whiteboard software *experience* in other tools like Prezi (Prezi Inc., 2025) and LucidCharts (Lucid Software Inc., 2025), but only Miro was *evaluated* in their study and therefore included in our results.

To address this limitation, our MLR included grey literature, where we reviewed tools and features from G2, a platform used to “make smarter software decisions based on authentic peer reviews from fellow professionals” (G2.com, 2025c). G2 define “collaborative whiteboard software” as “a shared, singular, and open design space where collaborators can simultaneously make edits and share content from their respective devices” (Nkrahene, 2025). To qualify for inclusion within the collaborative whiteboard category, a product must “provide a customizable and editable blank design space that can be accessed and used by multiple contributors simultaneously, offer design tools that allow users to draw and annotate, and be able to save the space” (Nkrahene, 2025).

When searching for “collaborative whiteboard” software on G2 in June 2025, we identified 116 listings. The top 10 according to “satisfaction and market presence” (referred to as the “G2 Score”) on the 13<sup>th</sup> of June 2025 (G2.com, 2025a), included Miro, Zoom Workplace (Zoom Communications Inc., 2025), Lucid Visual Collaboration Suite, Webex Suite (Cisco, 2025), ClickUP (ClickUP, 2025), Padlet (Padlet, 2025), FigJam, MURAL, Jamboard (which is no longer available according to Google (2025a)), and Freehand (which is a product by Miro). Notably, only three of the top 10 G2 tools were present in our PP, i.e., academic publications.

G2 facilitates tool comparison, which is the focus of our repository, presenting information such as an AI generated summary of the tool, the pricing, ratings, and *features*. However, this functionality in G2 has some limitations. When comparing Miro to MURAL using G2 based on *features* (G2.com, 2025b), many feature fields lack sufficient data (“not enough data” even when expanding the features as shown in [Supplementary Appendix F](#)). Another limitation of G2 is that the features rely on user reviews, which may introduce bias. Features are also not standardized across tools which complicates the comparison process, for example Miro has “Software Offering” with “In-Browser,” “Desktop App,” and “Mobile App” as options, Zoom Workplace has “Software Type” with “Mobile” and “Desktop Application” as options, and MURAL lacks any software type information.

To determine whether (and which) features listed by G2 have been excluded in our academic-based repository, we extracted and grouped the features listed in the top 10 collaborative whiteboard tools in June 2025. ClickUP was excluded as the primary focus of this tool and its features, indicated by G2, is project management. The G2-derived list of features, cross-referencing our initial repository, is included in [Supplementary Appendix G](#). We also observed that G2’s feature descriptions are often high-level and lack context. For example, G2 includes a design tool feature called “Templates” whereas our repository

has a section for “Template reusability” with *three* features, each with a detailed description. Amendments to the repository, based on the features identified from G2, are indicated in *purple* in Supplementary Appendix E.

#### 4.5. Validating the feature repository

To validate the repository, an individual interview was conducted with a postgraduate researcher who had experience in feature selection, the development of a feature selection tool within an *event management* context, and the use of Figma and MURAL. Ethical approval for this study was obtained from the Faculty of Engineering, Built Environment and IT Ethics Committee at the University of Pretoria (Approval No. EBIT/224/2024), and informed written consent was obtained from the participant.

During the interview, each feature was discussed, focusing on clarity and completeness. The postgraduate researcher recommended adding notes in the Excel sheet (Microsoft, 2025) to provide examples or further explanations where necessary, i.e., allowing users to access additional guidance or definitions (e.g., “board,” “full member” and “group”) when hovering over a cell. He further highlighted the need for more content in certain areas, such as gesture-based input and method guidance. Potential overlaps between features were also identified, for example, he questioned whether “construct editing control” should allow only one person to unlock it, which is already addressed under a feature in the *facilitator* control category (“locking some board contents”). To avoid confusion, it was suggested that such overlaps be clarified by explicitly indicating their relationship.

He also recommended the removal (or amendment) of certain nonfunctional requirements (NFRs) that are too subjective or difficult to measure, including “intuitive interface,” “easily referenced,” “visually appealing interface,” and “sufficiently large.” In addition, he proposed improving the readability of the repository by shortening certain sentences, correcting minor formatting and capitalization inconsistencies and addressing issues such as missing descriptions or duplicated features, e.g., “self-training” was listed twice, one of which should have been labeled “onboarding.” In some cases, he suggested splitting features for better clarity, for instance distinguishing between *designing* templates and *sharing* templates. He also noted that screensharing is an unnecessary feature, as this functionality is already implied in most modeling tools. Finally, he recommended incorporating a *cost* component or pricing plan to strengthen the repository. However, as price is considered an NFR (Leffingwell, 2011), an appropriate way of integrating this feature into the repository should be investigated.

### 5. Limitations and future work

This study has several limitations that should be acknowledged, including method-related limitations, results-related limitations, threats to validity, and AI tool limitations.

#### 5.1. Method-related limitations

Considering that less than 15 PP were identified, we acknowledge that the search method could have excluded some valid studies despite our best efforts to perform a comprehensive search. The search string was very focused, only searching for fragments within the *title*. We recognize this as a significant limitation that risks excluding relevant literature. However, this approach was a deliberate decision made to ensure the efficiency and focus of the review. As the sole researcher on this project, a broader search would have been time-intensive, potentially diverting time from the analysis of the most relevant studies. Therefore, the title-based search served as an efficient primary filter to quickly identify the core literature most central to our research questions. To mitigate the risk of exclusion, we used a two-step screening process. If the title alone was ambiguous or insufficient, we consulted the abstract and keywords to make a more informed decision.

Our inclusion criteria required *collaboration* or *participation* as concepts, and we therefore screened titles/abstracts for evidence of these concepts. As a result, some studies may have been inadvertently excluded if collaboration was not explicitly mentioned in these sections. An example is the study by Szopinski et al. (2017) which was excluded due to a lack of these themes, despite covering features

related to collaboration in the study itself. Terminology inconsistencies such as the interchangeable or undefined use of terms like “collaboration” and “model” may have also resulted in some studies being excluded. We also acknowledge that some foundational literature from the 1990s and 2000s, where collaborative features were discussed under broader terms, may not be fully represented in our findings. Additionally, the literature review was conducted by a single reviewer which may have introduced bias.

### 5.2. Results-related limitations

The extraction and synthesis of features to develop the repository depended on both human interpretation and AI assistance. Consequently, some misinterpretations may be present, even though we mitigated the risk by involving AI as a research assistant and using grey literature to supplement feature extraction. In addition, we also validated the list of features with an independent researcher. Since tools and their features are continuously updated, or discontinued, our results (the repository of features) may quickly become outdated. Grey literature sources, such as G2, are particularly dynamic and subject to frequent changes. For example, in June 2025, G2 listed 116 collaborative whiteboard tools, whereas by October 2025, this number had increased to 118. Maintaining the accuracy and relevance of the repository will be an ongoing challenge and future work should explore ways in which automated updates could be used while ensuring academic rigor.

### 5.3. Threats to validity

According to Zhou et al. (2016), the three highest threats to validity of SLRs in software engineering are: (1) Inappropriate or incomplete search terms in automatic search; (2) Bias in study selection; and (3) Bias in data extraction. To mitigate these risks, we conducted iterations of search string refinement, using synonyms as new terms were identified. Elicit and SciSpace were also utilized to further identify relevant studies, as well as forward and backward snowballing. Nevertheless, due to terminology limitations, some relevant studies may have been overlooked. To address *bias in study selection*, we included all the studies that adhered to our requirements (e.g., inclusion and quality criteria), and included as many studies as possible, including academic literature and grey literature. Lastly, regarding *bias in data extraction*, we documented repository versioning to track evolution and incorporated data from different sources, such as academic repositories and real-world reviewer feedback (G2.com, 2025c).

### 5.4. AI tool reflections

The AI tools used in this review are ever-evolving and assessment of their effectiveness may become outdated as new tools and features emerge. Additionally, limited experience with prompt engineering could have impacted the perceived effectiveness of these tools and therefore our reflections on their utility.

Several avenues for future work exist. It would be valuable to investigate enterprise modeling tools that exist outside the academic literature. Similar to the prototype, developed at the University of Rostock (Gutschmidt et al., 2019), many enterprise modeling tools may be available, but lack formal publication. A difficult, yet impactful, avenue would be to locate and analyze these tools to bridge the gap between academic research and practical applications. The repository should be regularly updated as new studies are published and as new PEM tools are identified/developed, e.g., through platforms such as G2.com (2025c) and from academic literature.

Exploring the use of AI and automated methods for literature screening and feature extraction to maintain the repository, could be beneficial. The repository and its relevant categories/features could also be further validated by other domain experts to strengthen the credibility and ensure completeness. By evaluating emerging features/needs and involving experts in the process, the repository could be further refined by introducing additional categories or sub-categories. As an example, the current *facilitator enablement* category, which includes functionality that supports facilitators in coordinating group activities, could be decomposed into separate sub-categories, like the “voting” feature listed by G2.com (2025c) for MURAL.

## 6. Conclusion

This study presents the results of an MLR on tool features that contributed to and/or hindered PEM. Current academic studies that evaluate online collaborative tools for PEM offer limited comparisons, e.g., only evaluating one or two tools. In this study, thirteen primary publications extracted from academic literature were used to develop a repository of tool features. An additional review of grey literature was used to further refine the repository.

The main contribution of this study is therefore a combination of results of previous evaluations of relevant tools. We also report on the role of emerging technologies, specifically AI, in supporting the traditional process of an SLR. The findings of the study can be used in future research work, e.g., expanding the repository and using automation and AI to ensure that the repository stays up to date.

## Author contributions

CRedit: **Anthea Venter**: Conceptualization, Investigation, Methodology, Project administration, Validation, Visualization, Writing – original draft; **Marne De Vries**: Conceptualization, Supervision, Validation, Writing – review & editing.

## Disclosure statement

No potential conflict of interest was reported by the author(s).

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## Data availability statement

Additional data supporting this study's findings are available from the corresponding author, A. Venter, upon reasonable request.

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