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Variable science mapping as literature review method

Przemyslaw Tomczyk¹ · Philipp Brüggemann² · Justin Paul³

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Abstract

This study investigates a novel mapping approach for the systematic analysis of empirical research, termed *Variable Science Mapping* (*VSM*). This approach enhances the current capabilities of *Systematic Literature Reviews* (*SLRs*) by incorporating variables and their interrelationships, surpassing traditional methods, such as *Science Mapping* (*SM*), which primarily analyze keywords, citations, and authorship. We present a step-by-step conceptual protocol for implementing the *VSM* approach. Subsequently, the strengths and limitations of *VSM* compared to *SM* are examined across 12 *SLR* stages. To this end, we assess the actual usage of *SM* for each stage based on an analysis of 63 papers employing the *SM* approach. Additionally, expert interviews are conducted to evaluate the utility of both *SM* and *VSM* across identical analytical stages. Notably, a distinct alignment emerged between the outcomes of the *SLR* and expert assessments pertaining to *SM*. The findings reveal *VSM*'s favorable ratings in eight out of 12 stages. Equivalence in expert ratings between *SM* and *VSM* surfaced in one stage, while *SM* was deemed more beneficial in three stages. This nuanced evaluation underscores the contextual strengths and limitations of both approaches. The implications extend to both scientific and managerial domains, offering valuable insights into the prospective advancements in *SLRs*. In conclusion, this analysis not only sheds light on the potential advantages of *VSM* but also serves as a foundation for guiding future research methodologies to widen capabilities among different *SLR* stages.

Keywords Literature analysis · Empirical mapping · Systematic literature review · Science mapping · Variable science mapping

Introduction

Systematic literature review (*SLR*) is a research method that enables the identification, selection, critical evaluation, and synthesis of existing literature in a rigorous, transparent, and repeatable manner, leading to robust conclusions about what is known and what is not known in peer-reviewed research areas (Christofi et al. 2021). According to Scopus, in 2022, 667 scientific articles in the field of management, accounting, and finance were published, in which a *SLR* was the basic one. Compared to 487 in 2021 and 379 in 2020, an upward trend close to exponential can be seen.

The procedure of *SLRs* can be complex. The use of this method requires a review question (Christofi et al. 2021;

Leonidou et al. 2018; Mcquade et al. 2021; Vrontis and Christofi 2019), data collection (Christofi et al. 2021; Mcquade et al. 2021), inclusion or exclusion criteria, selection of relevant studies, final database preparation (Leonidou et al. 2018; Vrontis and Christofi 2019), bibliometric analysis (Mcquade et al. 2021; Siemieniako et al. 2022; Vrontis and Christofi 2019), research results presentation in the form of thematic analysis (Leonidou et al. 2018; Mcquade et al. 2021; Siemieniako et al. 2022; Vrontis and Christofi 2019) or synthesis (Christofi et al. 2021; Leonidou et al. 2018; Vrontis and Christofi 2019), contribution presentation (Christofi et al. 2021), and developing a section on future research agenda (Paul and Menzies 2023; Christofi et al. 2021). One frequently employed technique in *SLRs* is *Science Mapping* (*SM*).

SM is used in bibliometric analysis, understood as a part of a *SLR* or a separate analysis to achieve visual data presentation (Chen 2017; Ghorbani et al. 2021; ElKattan et al. 2023). The current approach that dominates today consists of mapping areas, keywords, terms, authors, or citations (León-Castro et al. 2021). Numerous different software solutions

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exist for the generation of *Science Maps* (e.g., VOSviewer, CiteSpace, or SciMAT). In recent publications, *SM* has been used to perform extensive literature reviews, especially in areas with a relatively high number of publications, such as integrated marketing communication (Christian et al. 2021; Wu et al. 2022) or digital marketing (Aksoy et al. 2021; León-Castro et al. 2021; Gao et al. 2021). Despite the distinct advantages offered by *SM*, such as the comprehensive presentation of the research field from multiple perspectives and its ease of use, this approach is not without limitations. While this approach has strengths in analyzing papers on a descriptive basis, e.g., by considering keywords and citations, it might be impossible to investigate key variables, key theories, or antecedents and consequences of the studied literature. While this approach is limited to summarizing metadata, the degree of information extraction and the closeness to an appropriate picture of the underlying literature are severely limited (Tomczyk 2022). Furthermore, there has been little research on the boundaries of the *SM* approach, especially as limitations in research papers (e.g., Mavric et al. 2021; Zupic and Čater 2015).

While there is merit in using the approach of *SM*, it is constrained to the descriptive content analysis phase (Najaf et al. 2022). As such, this approach can hardly provide support at the first stage of the literature review, i.e., formulating a research problem. Therefore, researchers have criticized bibliometric reviews based on *SM* (Paul et al. 2021; Paul et al. 2023) because the theoretical contributions can be limited.

In general, the development of a domain area is based on the development of knowledge about variables as an expression of social phenomena. Progress is made by creating new variables, investigating new relationships, and analyzing these connections in different contexts. Surprisingly, there is no approach to systematically investigate such evolving variables and relationships.

Another widely recognized and commonly employed method in *SLRs* is *Meta-analysis* (Brüggemann and Rajguru 2022). This technique is particularly effective for examining selected relationships across multiple studies (Glass 1976) using specialized software. Despite its merit and relevance, *Meta-analysis* is constrained to offering an aggregated overview of selected relationships.

Differences within a given body of research, which encompass positive, negative, and non-significant results across several papers, cannot be fully addressed by *SM* or *Meta-analysis*. To address this gap, we propose a novel approach termed *Variable Science Mapping (VSM)*. This technique aims to conduct a comprehensive synthesis of relationships between variables in empirical research. Additionally, it provides a graphical visualization encompassing all variables and their interrelationships. Consequently, this new approach facilitates the presentation of the current state

of knowledge for any selected variable within any domain of the social sciences. This mapping technique is expected to be valuable both in formulating research problems and in analyzing content to address these problems.

In this study, our objective is not to determine whether *VSM* is superior to existing methods but to explore potential enhancements in *SLRs* through the application of *VSM*. To ascertain the appropriate contexts for using *SM* and *VSM* in *SLRs*, we first identify 12 relevant stages in *SLRs* based on the existing literature. We then conduct a *SLR* of 63 top-tier articles, examining the utilization of *SM* across these predefined 12 stages. Subsequently, through a series of in-depth interviews with experienced researchers in management, we investigate where and how *VSM* and *SM* can be beneficial in *SLRs*.

Synthesizing knowledge in *SLRs*

SM and *Meta-analysis*

To synthesize knowledge from scientific articles, researchers can utilize *SM* and *Meta-analysis* methodologies. *SM* usually employs citation, co-citation, and co-occurrence analyses to depict the knowledge bases within a field (Sanguankae and Ractham 2019). Using this approach, researchers can understand the relationships between scientific works and the evolution of knowledge within a domain. *SM* tools, such as bibliometric software, help visualize knowledge domains, literature, and citation networks (Chen 2017). These tools facilitate the identification of trends, influential works, and emerging topics within a field, aiding in the interpretation of extensive scholarly information, as well as mapping research landscapes and visualizing connections between studies (Cobo et al. 2011).

Meta-analysis, on the other hand, provides a quantitative synthesis of coefficients from multiple studies, allowing researchers to draw conclusions by analyzing empirical findings from various sources (Harlos et al. 2016). This statistical method is widely used across disciplines to aggregate and analyze results reported in different studies (Huang and Hu 2017). Through *Meta-analysis*, researchers can calculate effect sizes and assess trends or patterns present in the literature (Suciana and Sausan 2023). *Meta-analysis* offers a systematic approach to aggregating and analyzing data from multiple studies to draw overarching conclusions or identify patterns across research findings (Huang and Hu 2017). By applying meta-analytical techniques, researchers can quantitatively assess the consistency and magnitude of effects observed in different studies, providing a comprehensive understanding of a research question (Dolapçioğlu and Subaşı 2022). *Meta-analysis* is valuable in synthesizing evidence from diverse



sources and resolving discrepancies present in individual studies (Anjani 2023). By incorporating *Meta-analysis*, researchers can quantitatively analyze and synthesize data from identified studies, offering a rigorous and evidence-based approach to knowledge synthesis (Huang and Hu 2017).

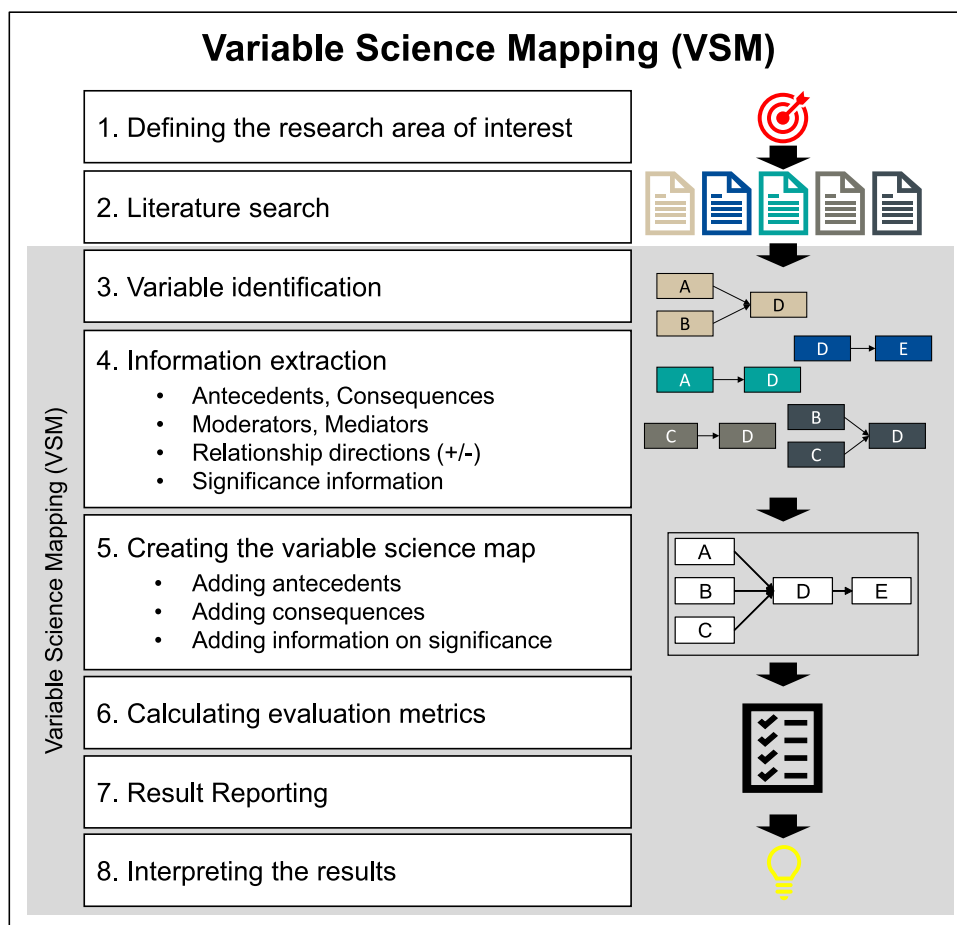
The integration of *SM* tools and *Meta-analysis* techniques enhances the understanding of complex research landscapes, providing a robust framework for synthesizing knowledge from scientific articles. However, these approaches also have certain limitations. *SM* cannot identify variables, relationships, or research models across different papers; it can only compare elements such as keywords and authorship between papers in a map. While *Meta-analysis* focuses on empirical studies and can analyze relationships, it does so only from an aggregated perspective across all examined papers, providing insight into specific relationships. *Meta-analysis* cannot create a depiction of the research implemented in the papers, nor can it analyze contradictory results, such as those with positive or negative coefficients, for further research. To address these limitations of current approaches, we introduce *VSM* in the next section.

The concept of VSM

This section introduces the *VSM* technique to extend the capability of *SLRs*. The rationale behind this approach is not to supplant *SM* or *Meta-analysis* but to enhance *SLRs* for empirical papers. We contend that this approach is particularly valuable in research areas with numerous empirical studies on similar topics. While *SM* can identify keywords, co-authorship, and other relevant elements for a specific variable, *VSM* aims to map all variables across the papers under investigation. This comprehensive mapping can offer researchers a more holistic overview of a predefined research field.

Tailored for systematic analysis of empirical research, *VSM* also complements the well-established method of *Meta-analysis* by capturing variables and relationships, examining commonalities and disparities across diverse papers. This approach, e.g., unveils potential research gaps or inconsistent findings. Figure 1 delineates the procedural steps involved in employing *VSM*. We detail these steps below following from a *VSM* protocol we suggest to follow when using *VSM*. Figure 1 presents a conceptual protocol for applying the *VSM* approach. This protocol can be utilized

Fig. 1 Conceptual protocol for applying the *VSM* approach



by researchers in future to implement the *VSM* approach step by step, thereby ensuring an adequate execution of this methodology.

Before incrementally implementing *VSM*, it is imperative to precisely delineate the research domain under investigation in step 1. This initial step holds significant importance as it profoundly influences all subsequent procedures. Opting for a broad research scope (e.g., technology acceptance in electronic commerce) will result in a correspondingly extensive and intricate *Variable Science Map*. While this breadth can offer a comprehensive overview of entire research streams, it also entails increased effort and complexity in analysis. For emerging and narrower research domains, *VSM* can serve to generate an overview of past research endeavors and extract potential future research directions.

Once the research field under scrutiny has been identified, the subsequent step 2 involves seeking pertinent literature. This phase should adhere to a structured approach akin to a *SLR* method, as advocated by Vrontis and Christofi (2019) and outlined by Paul and Criado (2020).

Upon completion of the preparatory stages, the application of *VSM* ensues in step 3. This involves the initial identification of variables within each of the articles under investigation. These variables might inherently represent antecedents, consequences, mediators, or moderators. It is imperative to note that a variable could serve diverse roles across multiple articles.

Following the identification of variables within each of the examined papers, step 4 involves extracting the necessary information for the *Variable Science Map*. This encompasses the identified variables (antecedents, consequences, mediation, or moderation), the analyzed directions of relationships and details regarding the significance of empirical findings. To facilitate information extraction, it might be beneficial to consider the figures or formulas portraying the empirical analyses within the papers, provided such information is available.

In step 5, all variables are incorporated into a model to depict the discovered relationships. This process results in a comprehensive research model based on the previously examined articles. Figure 1 illustrates, on the right side, an exemplary analysis of five articles. These five articles encompass five distinct research models, which are subsequently integrated into an aggregated research model. Following the creation of this aggregated model, details regarding significance and relationship direction (\pm or non-significant) can be documented.

In the subsequent step 6, the augmentation of evaluation metrics becomes pivotal for a more comprehensive contextualization of the analysis outcomes. These metrics encompass diverse dimensions, including the number of included papers, variables, identified relationships, the theoretical maximum of potential relationships, and instances of

conflicting results. Leveraging these descriptive specifics, various metrics can be calculated, such as the ratio of relationships derived from articles to the theoretical maximum, the proportion of conflicting results, or the prevalence of non-significant findings. Figure 3 serves as an illustrative instance, providing a portrayal of a *Variable Science Map* coupled with evaluation metrics.

In step 7, presenting the research results is recommended, involving the display of both the *Variable Science Map* and accompanying metrics. This inclusive approach offers a comprehensive view of empirical research within a specific field of study. Simultaneous consideration of the *Variable Science Map* and metrics aids in conveying and assessing the analysis's quality and extent.

Moving to step 8, the interpretation of findings relies on the *Variable Science Map* and evaluation metrics. By consolidating multiple empirical works, this approach enables result verification, identification of contradictory findings, and the revelation of further research needs. While deriving intricate empirical models is plausible, it is vital to stress caution in utilizing the resulting research model as a template for subsequent empirical research. The aggregation of multiple models may introduce statistical concerns, such as multicollinearity or endogeneity. In the next section, we will investigate the usefulness of *SM* and *VSM* related to 12 *SLR* stages. We have deliberately chosen *SM* as the comparative method because it is also a mapping approach, making it particularly suitable for comparison with *VSM*. It is important to note that *VSM* is not intended to replace *SM*, but rather to complement this established mapping approach.

Analyzing *SM* and *VSM* along *SLR* stages

Derivation of *SLR* stages

In this investigation, our focus centers on a *SLR* that incorporates the *SM* technique. Our primary aim is to contrast the approach outlined in this article with the established methodologies prevalent in the scientific community. Employing the *SLR* method recommended by experts (Vrontis and Christofi 2019; Paul and Criado 2020), we initiated our exploration using Scopus, the largest repository of peer-reviewed academic publications, employing widely accepted search algorithms (Glińska and Siemieniako 2018). Our search criteria comprised a specific string of three keywords related to *SM* along with the names of the two most widely software: VOSviewer and Citespace. Within the domains of management, finance, and accounting, our search yielded 590 occurrences in VOSviewer and 163 in Citespace from Scopus using title–abstract–keywords criteria. Subsequently, another *SM* application, Biblioshiny presented only 66 occurrences. The search string utilized is provided below for reference.



TITLE-ABS-KEY ("science mapping" OR "bibliometric mapping" OR "variable mapping" OR "vosviewer" OR "citespace") AND (LIMIT-TO (SRCTYPE, "j")) AND (LIMIT-TO (DOCTYPE, "ar")) AND (LIMIT-TO (LANGUAGE, "English")) AND (LIMIT-TO (SUBJAREA, "BUSI"))).

On December 27, 2022, we executed the string search, initially casting a wide net across the entire database. Given the extensive yield of several thousand results, we refined our search parameters to encompass only the categories of management, finance, and accounting. This focused approach yielded 532 articles. Subsequent analysis of the abstracts led to the retention of 443 articles. Among these, 12 lacked accessible PDFs, resulting in a final count of 431 articles for qualitative analysis. Applying the Academic Journal Guide (AJG) criterion, we sieved through these articles, ultimately selecting those falling within the 3, 4, and 4* categories. This meticulous selection process culminated in the final sample comprising 63 articles of high quality.

We analyze each of the 63 articles, gathering general information, such as software type, industry, mapping type, and research field. Furthermore, each article underwent an examination based on a *SLR* approach consisting of 12 distinct stages derived from Vrontis and Christofi (Christofi et al. 2021; Vrontis and Christofi 2019). Within these stages, spanning from review question identification to recommendations identification, we systematically checked whether the outcomes from *SM* were utilized. The 12 stages involved in this assessment encompass:

1. Review question identification,
2. Data collection analysis,
3. Bibliometric analysis,
4. Key variable analysis,
5. Key theories analysis,
6. Thematic clustering,
7. Antecedents' identification,
8. Consequences identification,
9. Research gap identification,
10. Trend identification,
11. Conclusions,
12. Recommendations identification.

In the subsequent section, in addition to presenting the outcomes of the *SLR*, we introduce findings derived from in-depth interviews. These interviews aimed to ascertain experts' perspectives on the usefulness of both *SM* and *VSM* concerning the 12 stages integral to *SLRs*, as previously delineated. Following this, we consolidate the *SLR* results regarding the use of *SM* in scientific research with the experts' evaluations and discuss the findings.

In-depth expert interviews

In the subsequent phase of our research, we conducted a series of nine in-depth interviews, adhering to the Kvale and Brinkmann (2018) methodology. Our participants comprised professionally active researchers in management, holding a PhD degree, and hailing from Poland and Germany. The experts were selected from our professional network. We deliberately chose experts who are not familiar with the topic being analyzed through *SM* and *VSM* methodologies to avoid potential bias arising from prior engagement with the subject matter.

For the interviews, we curated a set of five articles within the domain of customer ideas: Barasa et al., (2021), Burnham et al. (2020), Casaló and Romero (2019), Chan et al. (2015), Chan et al. (2021). This selection was deliberate, as these articles were deemed sufficient to reveal discernible differences between the methods under scrutiny. We reasoned that if disparities were clearly discernible within this limited set, their presence would be even more pronounced in a broader selection. Moreover, the field of customer ideas within management was chosen for its relevance and unfamiliarity to the participants, mitigating any foreknowledge bias. We generated two distinct maps: a conventional map using VOSviewer (aligned with the *SM* approach) and a variable map manually crafted (by the *VSM* approach). To create the *Variable Science Map*, we followed steps 3 to 6 as outlined in Fig. 1. Figures 2 and 3 within this context depict the visual representations presented to the interviewed experts.

The expert interviews followed a consistent protocol to avoid bias arising from different procedures. Initially, the experts were shown the conventional *Science Map*, which was briefly explained. Subsequently, for each of the 12 *SLR* stages, the experts were asked to assess whether *SM* could be effectively utilized at that stage. Afterward, the *Variable Science Map* was presented and briefly explained, and the same questions were posed. To facilitate comprehension during the interviews, succinct explanations were provided for both maps.

Figure 2 represents a visualization of keyword occurrences occurring at least twice, generated through the VOSviewer software. The visualization displays two distinct clusters, indicated by red and green colors. Specifically, the three keywords highlighted in red (i.e., idea generation, perceptions, word of mouth) were frequently interlinked within the analysis of the five articles. Similarly, the three keywords highlighted in green (i.e., participation, customer feedback, innovation) exhibited recurrent co-occurrences within this set of articles.

Moreover, Fig. 2 demonstrates instances where articles utilized keywords from both clusters (e.g., participation and idea generation). Notably, within the five articles under



Fig. 2 Conventional *Science Map* made with VOSviewer (according to the *SM* approach)

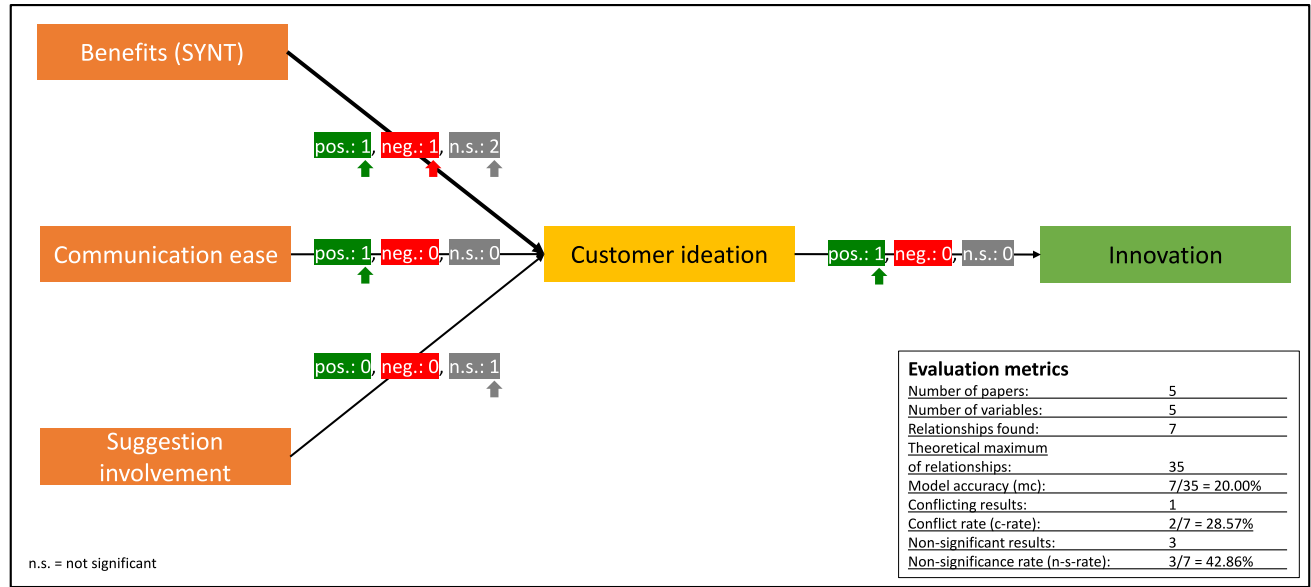
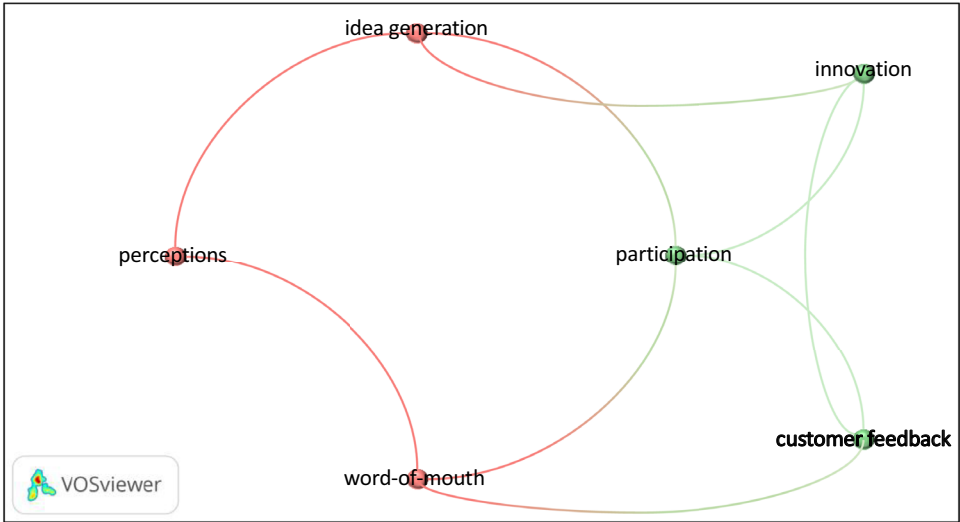


Fig. 3 *Variable Science Map* made manually by the authors (according to the *VSM* approach)

analysis, there was no instance of an article using both innovation and perception as keywords.

Figure 3 presents a manually created *Variable Science Map* developed by the authors in accordance with the conceptual protocol for applying the *VSM* approach, as outlined in Fig. 1. This map integrates information derived from the same set of five articles utilized in the earlier *SM* approach utilizing VOSviewer.

Figure 3 includes variable names, illustrating all investigated relationships, and enumerates the number of positive, negative, and non-significant empirical findings for each relationship within the subset of five papers utilized in our *SLR*. For instance, examining the relationship between

Benefits (SYNT) and Customer ideation, our analysis revealed one positive, one negative, and two not significant outcomes among the five articles scrutinized. This finding underscores the ambiguity inherent in the current empirical results uncovered by the *VSM* approach. Furthermore, within this limited subset, only one of the five articles explored the association between Customer ideation and Innovation, detecting a significant positive relationship. However, the *VSM* approach identifies potential avenues for further investigation to validate these outcomes. It is important to note that these conclusions can only be tentatively drawn when comprehensive literature pertinent to the research question is considered. In our instance, the analysis was limited to a



small set of five articles. Nonetheless, this illustrative example underscores the significant utility of the *VSM* approach in facilitating multifaceted insights.

Figure 3 is accompanied by descriptive information and precision metrics. It is important to note that the research models under scrutiny have not yet undergone evaluation by expert judges. However, their presentation here serves as an exemplar of the sixth point within the *VSM* protocol, as outlined in Fig. 1. Exactly as with the presentation of the conventional *Science Map*, evaluation of these consolidated research models was conducted by experts. This evaluation relied on a succinct description of the *Variable Science Map* provided by the interviewers.

Drawing inspiration from the application of goodness-of-fit metrics in statistical methodologies, such as regression or structural equation models, we propose methodologies aimed at offering a comprehensive evaluation of information generation and the precision inherent in *VSM* outcomes.

Initially, we present the count of articles (5) and variables (5) identified in our analysis. Following this, we enumerate the relationships revealed through the *VSM* approach (7). Subsequently, utilizing this data, we calculate the theoretical maximum number of relationships attainable within this analytical framework ($5 \times 7 = 35$). However, it is crucial to note that this theoretical maximum is seldom achieved in *VSM* analyses due to continual refinements in research models and relationships, often aimed at generating novel insights in response to evolving circumstances. Despite this, using the Theoretical Maximum of Relationships (35), we derive the Model Accuracy (MA) as a ratio of observed relationships to the theoretical maximum ($7/35 = 20\%$). This metric functions as an indicator of the comprehensiveness concerning the analysis of relationships within the papers under consideration.

An additional vital metric pertains to conflicting results, where the occurrence of both positive and negative significant outcomes in a relationship denotes a conflicting result. From these instances, we compute the Conflict Rate (CR) to gauge the prevalence of conflicting results relative to all relationships identified using the *VSM* approach. For instance, within our analysis (Fig. 3), with 1 conflicting result among 7 relationships, the indicative CR stands at 28.57% ($2/7$). This metric aids in identifying ambiguous or contradictory findings, potentially uncovering lacunae in existing research and illuminating unexplored research avenues.

Further aiding our evaluation is the Non-Significance Rate (NSR), calculated by determining the ratio of non-significant results (3) to all identified relationships (7), resulting in an NSR of 42.86% ($3/7$). This illustrates that 42.86% of the relationships studied in the five articles lacked statistical significance.

These metrics offer valuable insights for researchers and practitioners, enabling the assessment of result value,

identification of disparities among articles, and the identification of research gaps. While long-term utilization necessitates defining thresholds akin to quality measures in regressions or structural equation models, immediate establishment of substantial thresholds for valuation remains elusive due to limited practical experience. Rigorous testing and comparison of numerous *VSM* results are imperative for establishing credible thresholds.

Results

In Fig. 4, the temporal distribution of the 63 articles utilized for the *SLR* is depicted. Notably, all these articles utilize the *SM* approach, as *VSM* does not currently appear in the prevailing literature. Until 2017, the utilization of the *SM* approach was sparse, evident only in isolated articles. However, a noteworthy surge in publications commenced in 2018, with a substantial spike observed in 2021. Remarkably, the dynamics illustrate a significant and consistent increase in the number of high-quality articles employing the *SM* approach, extending until the conclusion of 2022. Despite relatively modest absolute figures, the discernible trend in Fig. 4 underscores the growing popularity of the *SM* approach as a preferred research methodology within top-quality articles.

Following the acknowledgment of the escalating importance of the *VSM* approach, our focus now shifts to presenting, comparing, and interpreting the outcomes derived from distinct investigations—specifically, the findings obtained from our *SLR* and the in-depth expert interviews pertaining to *SM* and *VSM*. Summarizing these results, Fig. 5 presents values transformed into percentages. For instance, the uppermost black bar depicted in Fig. 5 indicates an 83% value, signifying that within the 63 articles, the utilization of *SM* for thematic clustering amounted to 52 instances.

Observing the black bars within Fig. 5 reveals that in six out of the 12 stages analyzed, the utilization of the *SM* approach exceeded 20% in our literature review. Notably, researchers predominantly employed *SM* (83% occurrence) for thematic clustering. Furthermore, we identified two stages where a mere 3% of the articles (i.e., 2 out of 63 articles) incorporated *SM*, while *SM* was absent in four stages. The absence of *SM* usage in identifying key variables, antecedents, and consequences can be attributed to a fundamental limitation: *Science Maps* do not facilitate their identification. Operating primarily on keywords that do not always represent variables, these maps lack the capacity to decipher and report the strengths of relationships among variables. This limitation stands as one substantial constraint within the *SM* technique.

Interestingly, our investigation indicate a disparity between the perceptions of experts we interviewed and the



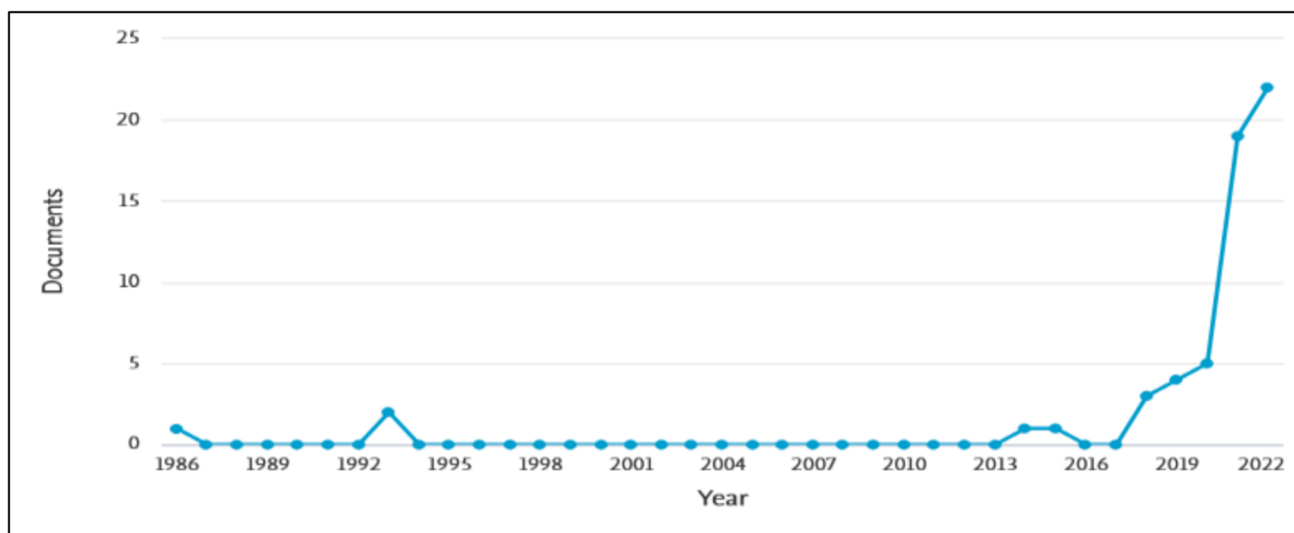


Fig. 4 SM usage trend (quality criteria: minimum AJG 3; $n=63$)

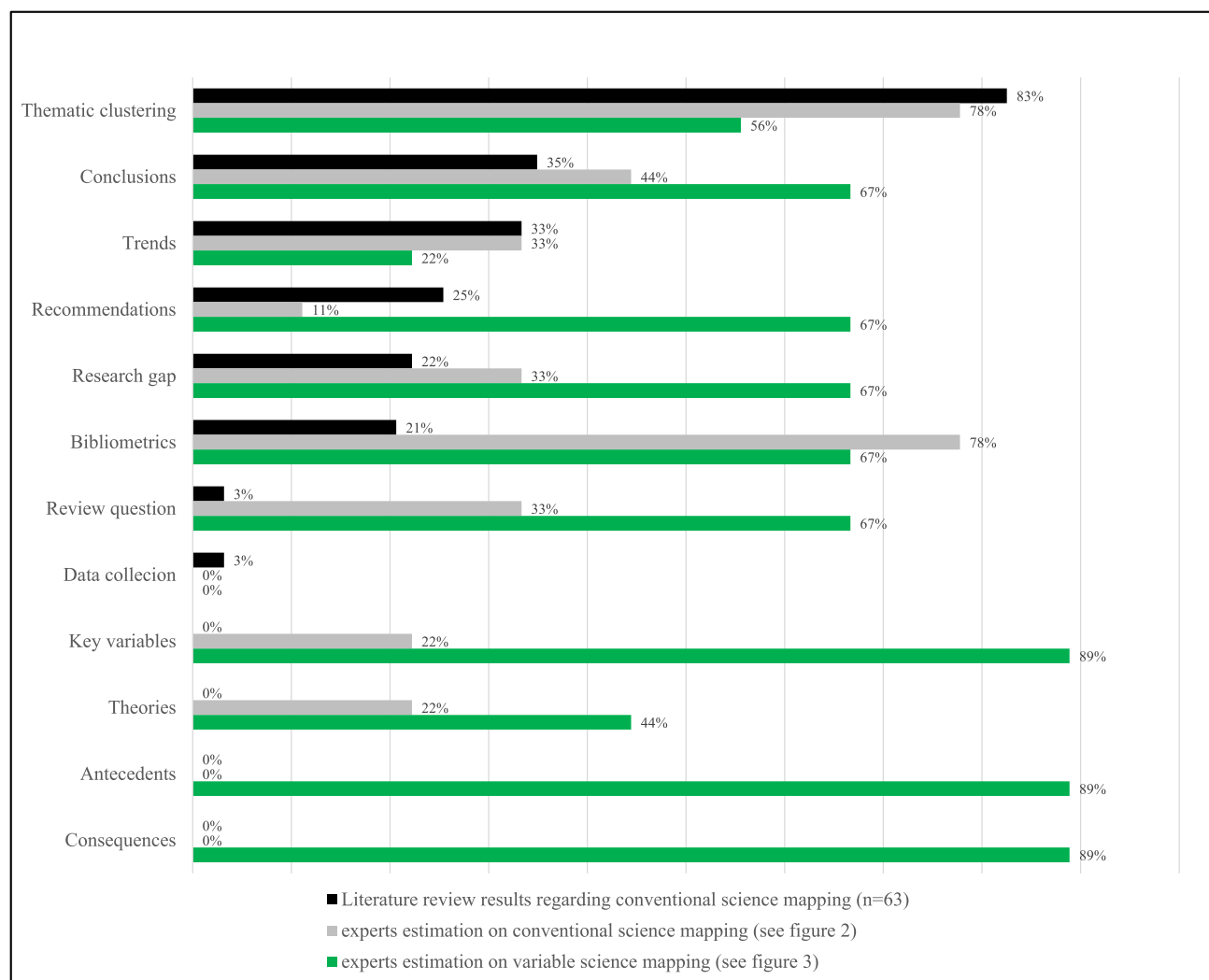


Fig. 5 Presentation of the results from three different investigations on SM and VSM



authors of the discussed articles (as depicted by the black bars vs. gray bars in Fig. 5). Experts seem to perceive greater potential for *SM* utilization compared to usage in the publications investigated. This discrepancy might stem from researchers' expectations that *SM* could potentially aid in identifying key variables or theories, possibly through keywords. However, the practical application faces the risk of limited identification due to the absence of certain variables or keywords within the *SM* framework. As a result, *SM* has seen limited use in these specific stages.

Beyond the outcomes regarding the expert interviews on the efficacy of *SM*, these interviews also address the viability of *VSM* as an alternative technique. Illustrated by the green bars in Fig. 5, these results from the expert interviews delineate opinions regarding the potential utility of *VSM* across different stages within a *SLR*. The distribution of opinions notably indicates a consensus favoring the feasibility of *VSM* adoption in nearly every stage, barring data collection. Expert opinions align unanimously in highlighting the benefits of *VSM*, affirming its capacity to 'reveal gaps,' 'identify obscure trends,' 'optimize time,' 'facilitate preliminary analysis,' 'identify contentious research,' 'aid in positioning papers,' 'direct research focus,' 'assist in research proposal preparation,' 'provide clarity on research objectives,' and 'highlight ambiguities.'

Figure 6 serves to depict the convergence and divergence among the outcomes from the three investigations: the *SLR*, expert interviews on *SM*, and expert interviews on *VSM*.

The findings underscore several critical observations. Firstly, the utilization of *SM* is limited, as evidenced by the black line in Fig. 6. Secondly, a discrepancy emerges

between the current practical implementation of *SM* and the researchers' estimations of its theoretical application potential, depicted by the divergence between the black and gray lines in Fig. 6. Lastly, the most pivotal observation involves the experts' anticipation of *VSM*'s utility across a significantly broader spectrum of stages within the *SLR* process, as indicated by the green line in Fig. 6. This pronounced difference illuminates the substantial potential and relevance inherent in the emergent approach of *VSM*. However, Fig. 6 also reveals that *SM* is superior to *VSM* for thematic clustering. This is demonstrated both by the results of the literature review, indicating how *SM* is actually utilized and by the assessments of experts.

Discussion

Conclusion

This research sought to compare the usefulness of *SM* and *VSM* across 12 stages pertinent to *SLR*. In the first step, a comprehensive analysis of 63 top-tier articles utilizing *SM* across these 12 stages was conducted. Subsequently, experts were consulted to evaluate the usefulness of both *SM* and *VSM* across these established stages.

Our findings show consistency between the outcomes derived from the *SLR* and the expert interviews concerning *SM*. Additionally, the expert assessments identified *VSM* as more applicable than *SM* in eight out of the 12 stages. Notably, for the 'data collection' stage, experts rated *SM* and *VSM* equally, while *SM* was considered more useful

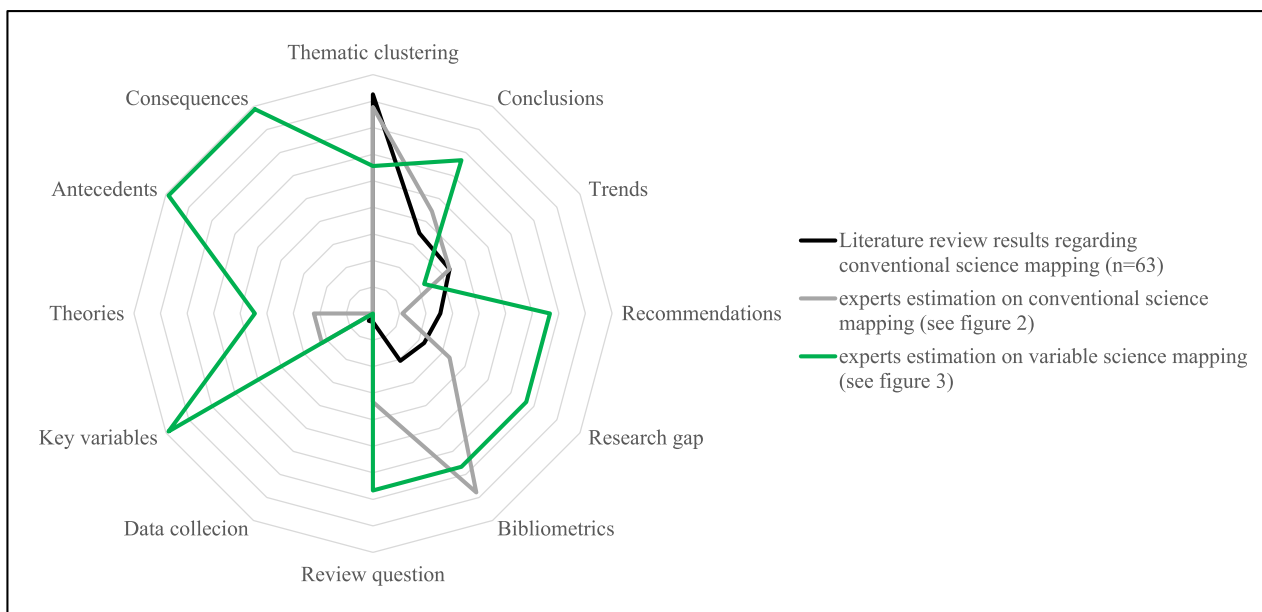


Fig. 6 Comparison of the three different investigations on *SM* and *VSM*



than *VSM* in three stages: bibliometrics, thematic clustering, and trends. This result clearly indicates that *VSM* is not a replacement approach but rather a complementary approach for other stages of *SLRs*.

The outcomes of our investigation offer several key insights. Firstly, we identified a discrepancy between researchers' estimations of *SM*'s usefulness in several stages and its actual application. Notably, this gap was pronounced in bibliometric analysis, review question identification, key variable analysis, key theories analysis, and research gap identification. Furthermore, *VSM* demonstrated coverage across 10 out of the 12 phases of *SLR*. Its most significant contribution lies in unambiguously identifying the key variables within analyzed articles, along with their antecedents and consequences, a capability previously unattainable.

Scientific and managerial implications

From a scientific standpoint, these findings represent a significant advancement in the ability to synthesize scientific research outcomes. The introduction of *VSM* empowers researchers to discern variables and their interrelationships, surpassing the capabilities of existing methods, such as *SM* or *Meta-analysis*. The incorporation of novel metrics like the Theoretical Maximum of Relationships, MA, and CR (Fig. 3) offers a quantifiable portrayal of the research field's contributions. This amalgamation of indicators, coupled with graphical representations, facilitates rapid assessments of a field's current state of knowledge. This has the potential to drive the publication of higher-quality, value-added research, consequently expediting scientific advancement.

From a managerial perspective, it paves the way for an efficient transfer of knowledge from the realm of academia to practical applications in the economic domain. Presently, the flow of knowledge from social sciences to practice remains limited. The time constraints inherent in mining specific problem-solving scientific results from numerous papers hinder practical application. However, an automated utilization of *VSM* holds promise in circumventing these limitations. This automated approach could potentially enable companies to access aggregated expertise on specific issues derived from a vast body of research. Such a methodology could foster collaboration between research and industry by providing companies with comprehensive, aggregated insights at a manageable cost—a feat currently challenging and prohibitively expensive.

Finally, from the authors' perspective, this novel approach has the potential to transcend the boundaries of *SLR*, rendering it not only accessible but also user-friendly for both researchers and practitioners alike.

Limitations and future research directions

This research is the first to propose the concept of *VSM*. The findings indicate that while *SM* is justified for certain stages, *VSM* can be applied effectively in numerous other stages. However, these initial results require further investigation in subsequent research.

In this study, the example of idea creation was examined using five papers; future research should explore *VSM* with different topics and a larger number of papers. Additionally, the experts did not create the *Variable Science Maps* themselves, so they did not factor in the effort required to construct such maps in their evaluations. In large research areas with a substantial number of papers, the effort to create *VSM*, similar to *Meta-analysis*, can be considerable. Moreover, a comparison between *VSM* and the *Meta-analysis* approach was not conducted in this study. Although *Meta-analysis* focuses on individual coefficients rather than providing an overview, a comparative analysis of the *Meta-analysis* approach could be valuable in determining when each approach (*SM*, *Meta-analysis*, *VSM*) should be utilized.

The *VSM* approach offers an opportunity for researchers in all fields to explore and examine the widely used variables (dependent, independent, control, mediating, and moderating variables). The qualitative approach of asking experts to evaluate the usefulness of *SM* and *VSM* across different *SLR* stages could be supplemented in future research by further observations or experiments. For example, an intriguing avenue for exploration involves having researchers analyze given papers using both *SM* and *VSM* methodologies. The resulting analyses could then be juxtaposed and evaluated through interviews with researchers utilizing the 12-stage approach. This comparative analysis stands to provide invaluable insights into the strengths and limitations of the novel method introduced in this research.

Another avenue for further research is the application of *VSM* to additional fields. Applying *VSM* in expansive research domains, such as empirical studies based on the Technology Acceptance Model (TAM) or the Unified Theory of Acceptance and Use of Technology (UTAUT), can yield novel insights. For instance, it could shed light on the researcher's preferences between TAM and UTAUT, revealing which relationships often lead to specific outcomes. Additionally, employing the *VSM* method could facilitate the creation of a comprehensive model, aiming to amalgamate these widely debated models.

In subsequent research endeavors, there exists the potential for integrating the *VSM* approach with the widely acknowledged technique of *Meta-analysis*. While *Meta-analysis* scrutinizes average coefficients among



independent and dependent variables, it runs the risk of obscuring individual findings. Consequently, a tenuous correlation may imply ambiguous empirical outcomes or genuinely feeble overall coefficients. Unlike the *VSM* method, which refrains from providing average coefficients and instead offers a comprehensive overview of all studied causal relationships, merging these approaches could seamlessly integrate the outcomes of *Meta-analysis* into the *Variable Science Map*. Such integration holds promise for significantly augmenting the explanatory prowess of *SLRs*, particularly in exhaustive analyses.

The integration of the *VSM* approach into existing frameworks should be analyzed in future research. For instance, this includes established frameworks, such as TCCM, 6W, SPAR-4-SLR, and Antecedents, Decisions, and Outcomes (ADO) (Paul and Rosado-Serrano 2019; Paul et al. 2021, 2023; Basu et al. 2022). The *VSM* methodology, which delineates relationships among antecedents, dependent variables, and their consequences, seamlessly integrates into the TCCM procedure, specifically within the “characteristics” section. This segment focuses on elucidating the constituents of a construct and their interplay with other pertinent variables in the study.

Finally, an additional avenue for future research is the automation of data extraction in the application of *VSM*. For example, utilizing artificial intelligence to automatically scan all selected papers and extract relevant information could result in significant time savings. This would enable the rapid replication of *Variable Science Maps*, thereby providing both academia and industry with an efficient overview of research on specific topics or research questions. Moreover, automating the literature search itself could drastically transform the entire process of literature review and evaluation (Tomczyk et al. 2024). However, it is essential to ensure the accuracy of the results; only with this assurance can these potential advancements aid society in effectively accessing and reliably utilizing the ever-growing body of knowledge.

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Declarations

Conflict of interest On behalf of all authors, the corresponding author states that there is no conflict of interest.

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