**Journal of Applied Informatics and Computing (JAIC)**
Vol.10, No.4, August 2026, pp. 3207~3219
e-ISSN: 2548-6861


# Problem Statement Formulation in Computing Research: A Systematic Review and a Proposed Computing-Specific Framework

**Tirivashe Mafuhure [1]*, Mampilo Phahlane [2]*, Charles Mbohwa [3]***
* Department of Information Systems, University of South Africa, South Africa
mafuht@unisa.ac.za [1], phahlmm@unisa.ac.za [2], mbohwc@unisa.ac.za [3]

**Article Info**

***Article history:***

Received 2026-04-23
Revised 2026-06-16
Accepted 2026-08-07

***Keyword:***

*Problem Statement,*
*Formulation,*
*Computing Research,*
*Systematic Review.*

**ABSTRACT**

The development of a well-formulated problem statement is still considered an integral but often insufficiently addressed step of the research process within computing research. Although essential for creating coherent research, selecting adequate methodology, and making scientific contributions, there is still no specific guidance on the development of computing-relevant research problem formulations, structuring, and formulation practices. This paper provides a systematic review of how the research problem is conceptualized, formulated, and operationalized in computing research. It aims to determine the common methodological problems of problem formulation, and to explore the methodological practices, recurrent strengths, weaknesses, and uniqueness of problem formulation in computing research. The systematic review was performed following the PRISMA protocol by analysing peer-reviewed journal articles published between 2014 and 2026 in major scientific databases such as IEEE Xplore, ScienceDirect, SpringerLink, and DOAJ. The search resulted in the identification of 57 papers. In turn, 16 articles met the inclusion and exclusion criteria after conducting screening, eligibility, and quality assessment. Thematic synthesis using open coding, axial coding, and theme development was utilized in order to analyse the data. Five recurring methodological weaknesses of problem statement formulation in computing research were identified are topic-problem confusion, solution orientation in early stages of problem formulation, poor empirical support, inadequate contextualization, and poor methodological alignment. Moreover, several significant discipline-specific differences in terms of problem conception were found. Some methodological approaches were detected in computing research. At the same time, their use appeared inconsistent and poorly coordinated across computing disciplines. Hence, the research proposes the Problem Statement Formulation Model (PSFM) as a structured methodological framework for problem formulation within computing research. PSFM consists of five consecutive steps that are context analysis, evidence-based gap recognition, problem structure creation, significance justification, and problem formulation. In contrast to existing generic frameworks, the presented model introduces an integrated methodology specifically adapted to the computing field. The paper concludes by discussing the findings' contribution to methodological guidance, postgraduate supervision, and training of researchers in computing disciplines.



## I. Introduction

Problem statement formulation is one of the key methodologies in formulating research questions and defining the parameters that guide the entire process. The problem statement in computing research is a scientific description of an unexamined technical, methodology, organizational, or socio-technical dilemma which requires careful analysis [3], [10]. Good problem formulation enables researchers to gain theoretical clarity in understanding why a study is relevant, formulate coherent research goals, methodologies and provide a platform for contributing to science [3]. Poorly crafted problem statements often result in vague research objectives, poorly formulated methods of collecting data, lack of integration in the data collected, and conclusions which have no meaning theoretically or practically [3], [10], [13].

Though research in computing science involves common methodology, there is significant variation in how problems are defined due to disparities between computing paradigms, epistemology, and technological goals [3], [6], [16] . In artificial intelligence and machine learning, problems usually revolve around such themes as prediction, fairness, explainability, scalability, and bias in algorithms. Software engineering research problems often emerge out of maintenance issues, low software performance, ineffective testing, or requirements engineering [2], [15]. Research in cyber security typically formulates problems in terms of detecting threats, exposure to risks, vulnerability, resilience, and security awareness [2], [15]. Human Computer Interaction research emphasizes usability, accessibility, human factors, and the effectiveness of interaction, while information systems research typically defines problems in terms of efficiency, adoption of technologies, decision support, and digital transformation [15] . It is, therefore, apparent that one size does not fit all in the formulation of computing research problems.

While the increasing emphasis on the significance of problem formulation in the creation of research is well-known, the guidance in terms of methods for research writing is scattered, incoherent, and poorly adapted to the particularities of computing research [2], [5], [15] . Current studies offer mostly general guidelines for research writing and methodological issues which fail to account for specific challenges posed by computing research, such as fast-paced technology developments, complex socio-technical systems, design-oriented research, algorithm development, and the distinction between technological product invention and scientific problem research [1], [14], [13]. Additionally, current studies fail to account for context analysis, gap identification, methodological match, and practical formulation issues in the construction of computing-specific research. This results in the presence of common methodological problems in the form of vague problem formulation, solution-focused problem definition, lack of contextualisation, and mismatch between problem statements and methodology [2], [14], [15]

The emergence of generative AI and large language models (LLMs) has also led to yet another transformation of the problem-formulating process in computer science. It has become more common for researchers to use AI-based assistance in searching for information gaps, formulating their ideas, and writing down their problems [9], [8], [10], [11] While the use of such technologies might facilitate the work of a researcher and expand their horizons, the fear exists that this could lead to over-dependence on the use of AI, superficial gap analysis, generation of hallucinations, and lack of proper grounding of research problems in context [9], [10], [11].

Thus, a methodological gap needs to be filled regarding an overview of how problem statements have been formulated and defined within various computing fields. This methodological issue should not be underestimated due to the growing relevance of emerging technologies and interdisciplinary research, where problem definition plays a significant role [9], [10], [11] . In order to address this issue, the current study performs a systematic literature review to analyse problem statement definitions, problem formulation approaches, common strength and weaknesses, and methodological patterns. The current study also develops a computing-specific Problem Statement Formulation Model (PSFM).

The review was guided by four research questions. Research Question 1: What conceptual definitions exist for problem statements in computing research? Research Question 2: What theoretical models, approaches, and methods are used in the development of problem statements in computing research? Research Question 3: What are some common attributes or trends in the formulation of problem statements that have been found in the existing literature on computing? Research Question 4: How can a computing-specific model be used to improve the problem statement development process in computing research?

As compared to past studies, which only provide general methodological guidelines, the current study provides a computing-based synthesis of practices associated with problem statement formulation and presents a Problem Statement Formulation Model (PSFM) based on insights gathered from the relevant literature. This methodological framework not only provides a solution for past problems but adds value to current methods by incorporating context analysis, identification of gaps based on evidence, problem formulation, and justification.

## II. METHODOLOGY

In the current study, a Systematic Literature Review (SLR) approach was used to critically analyse scholarly studies that focused on the formulation of problem statements in computing research. The study followed the PRISMA guidelines to provide methodological consistency, reproducibility, and rigour in the process of identification, selection, appraisal, and inclusion of the identified studies. This study sought to understand how problem statements are formulated, structured, and operationalized in computing research by identifying the common weaknesses in methodological approaches and strengths in the field, all of which guided the creation of the PSFM model. Considering the diverse nature of the literature used, qualitative synthesis appeared to be a more suitable analytical strategy than meta-analysis in this case.

*A. Search Strategy*

The study did an extensive search across many academic databases and scholarly engines that included Scopus, Web of Science and DOAJ to get peer-reviewed journal articles and conference papers that helped in answering the formulated research questions. The search targeted publications done from January 2014 to March 2026, with the final search done on the 5th of March 2026. Articles included were limited to English language peer reviewed publications. The literature included covered articles published between January 2014 and March 2026. The reason for using the first year, 2014, as a starting point was due to its significance in providing insights on modern methodological approaches that apply to the dynamic field of computing literature, which involves areas such as artificial intelligence, Cyber Security, and digital innovations. Although 2026 is not a complete year for the purpose of publishing articles, inclusion is justified since the last search of the database was conducted in March 2026 to ensure that the most updated peer-reviewed literature was accessed.

A systematic approach to searching was taken to ensure that maximum retrieval precision and comprehensiveness were achieved. Preliminary searching was done to systematically refine the search strings to enhance relevance and cut down on retrieval noise. There were three main categories of keywords: (1) problem statement language, (2) computing fields, and (3) language for methodology. Boolean operators (AND, OR) were applied in combining the clusters of keywords and controlling the breadth of retrieval.

Search syntax was crafted to fit the indexing needs of each database while maintaining consistency in concept across searches. The finalized search string included permutations of keywords pertaining to the problem statement, research problem, and problem formulation, alongside computing fields like computer science, information systems, software engineering, artificial intelligence, cyber security, and data science, as well as language for methodology in the form of terms such as framework, guideline, research design, and best practice. This is shown on Table S1 in the supplementary document.

The review process of literature was done in four major scientific databases, which have strict standards for indexing and contain computing-related scholarly articles: IEEE Xplore, ScienceDirect, SpringerLink, and Directory of Open Access Journals (DOAJ). Such selection was based on the fact that these databases index scholarly articles, conference papers, and methodological papers relating to the field of computing, information technology, software engineering, artificial intelligence, cyber security, and research methodology. Using scientific databases improved the quality and reproducibility of the process of conducting the review.

An iterative search approach was used to ensure that maximum precision was achieved during the search process. The search phrases were further refined during the pilot searches to improve their accuracy and reduce the number of irrelevant results. The following three key themes emerged: (1) keywords regarding the problem statement, (2) computing field, and (3) methodology keywords. The Boolean operators (AND, OR) were used to combine the keyword themes and to control the breadth of the search. Each database had its specific indexing needs that had to be considered when formulating the search syntax. The final search phrase comprised the problem statement keywords and the computing field keywords in combination with methodological keywords such as framework, guideline, research design, and best practice. The computing field keywords included computer science, information systems, software engineering, artificial intelligence, cyber security, and data science among others. The study utilised a core search string as follows. (“problem statement” OR “statement of the problem” OR “research problem” OR “problem formulation” OR “problem definition”) AND (“computing” OR “computer science” OR “information systems” OR “software engineering” OR “informatics” OR “artificial intelligence” OR “cyber security” OR “data science”) AND (“framework” OR “model” OR “guideline” OR “methodology” OR “best practice” OR “research design”). This is shown on Table S1 in the supplementary document.

*B. Data inclusion and exclusion strategy*

Inclusion and exclusion criteria were predefined for methodological consistency and replicability in the process of study selection. The studies that had to meet the specified criteria included: (i) studies that had to do with computing disciplines (computer science, information systems, software engineering, artificial intelligence, cyber security, human-computer interaction, or data science); (ii) studies in which issues related to research problem formulation and problem statement development or methodology structuring were addressed; (iii) studies contributing to theoretical, empirical, or methodological knowledge related to problem statement formulation; (iv) peer-reviewed journals, conference papers, academic books, and methodology studies; and (v) studies written in English and featuring accessible full-text versions.

Exclusion criteria encompassed studies that focused exclusively on system development from a technical perspective without any methodological consideration of research problem formulation, studied disciplines that did not have methodological value for addressing research problems, featured no accessible full texts, and discussed research problems marginally. For the purpose of strengthening the reliability of the methodology and eliminating subjectivity among reviewers while making decisions about including or excluding articles, the screening and assessment of eligibility was done by two independent reviewers. Any disagreement regarding the inclusion or exclusion criteria was sorted out via discussion until consensus was reached, and when necessary, the review criteria acted as the decision-making tool. Supplementary Table S2 shows the data inclusion and exclusion strategy.

### *C. Study selection Process*

For the screening process, the selected articles were independently screened by two researchers against pre-established eligibility criteria. Records that only concentrated on the technical aspect of the system development without methodological explanation regarding the formulation of research problems, studies that did not relate to computing field issues or failed to show methodological relevance of their studies to the problems being addressed, and those which lacked substantial problem statement discussions were excluded. These excluded a total of 23 articles, leaving 28 articles for eligibility assessment.

For the eligibility assessment process, 12 more articles were excluded because of lack of proper discussion on research problem formulation, inadequate methodological contribution in addressing the review questions, and lack of methodological relevance to the study. Therefore, 16 articles passed the eligibility stage and thus included in the thematic synthesis. Any disagreements between the two researchers on exclusions were sorted out through consensus discussions. Figure 1 below shows the whole PRISMA process.

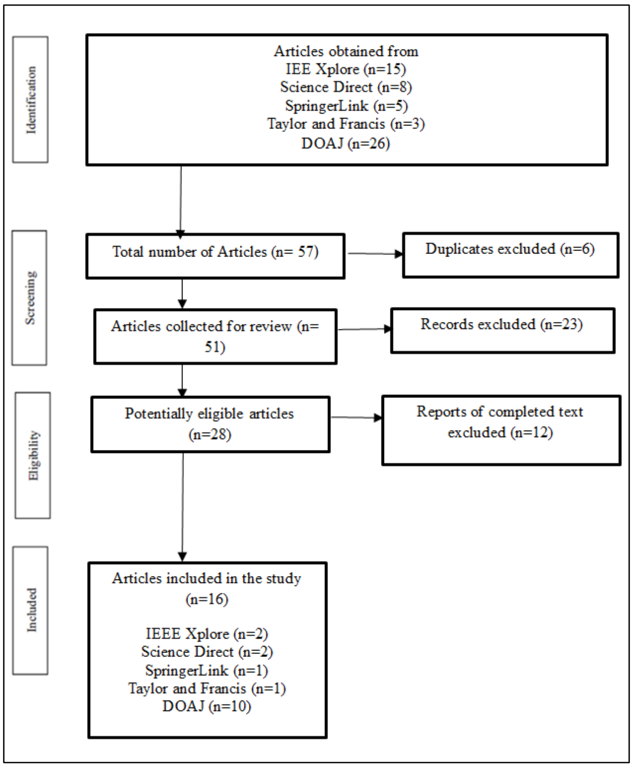


Figure 1. PRISMA Diagram

### *D. Quality Appraisal*

All the included studies received structured quality evaluation as well as risk of bias analysis in order to improve the methodological rigor of the study. Since the chosen literature included empirical, theoretical, as well as methodological literature, a specially designed quality assessment checklist was designed based on the general rules for systematic reviews. There were five categories evaluated according to their quality levels, namely: relevance of the chosen article to the problem, the clarity of its goals, methodology used quality of evidence or argumentation presented, and applicability to the research of computer science. Overall, out of 16 reviewed sources, nine (56.3%) studies were determined to be high-quality, scoring from 8 to 10, while the remaining seven (43.7%) studies received a rating of moderate quality, with scores from 5 to 7. As shown on Table S3 in the supplementary document, none of the articles have been assessed as low-quality, which means that all of the reviewed sources met the minimum threshold of quality predetermined for this literature analysis. The most common scores received by the sources are 7 and 9, which are presented by five studies each (31.3%), and 10 – by three studies (18.8%). Only one source has obtained the score of 6 (6.3%), as well as the other source that scored 5. Speaking about the appraisal criteria, most sources demonstrated relatively high-quality standards concerning relevance to the problem formulation and clarity of purpose, with maximum scores being attained in relation to these criteria. Meanwhile, the weakest scores concerned the issues of methodological transparency, evidentiary basis of the arguments or results, and applicability to the computing field. Nevertheless, the majority of high-quality papers makes the results of thematic analysis reliable and proves the feasibility of creating the Computing-Specific Problem Statement Formulation Framework. This is shown on Table S3 in the supplementary document.

### *E. Risk of Bias assessment*

All possible biases were clearly stated and taken into account during the review process. This included publication bias that might occur in favour of highly cited studies, language bias because of the restriction to English language articles, disciplinary bias due to the variety of methods used in different disciplines of computing, and indexing bias arising out of search differences among databases. The way that all those biases were mitigated is by using more than one database.

### *F. Data extraction process*

The study used a structured data extraction process to ensure accuracy, consistency and systematic organisation of information from the studies included. The study developed a standardised extraction form to capture and organise study findings and characteristics. Important information extracted from each study included Authors, publication year, publication source, computing domain, definition of the problem statement, frameworks utilised, strengths and weaknesses noted, practical recommendations, relevance of the study to computing research and quality appraisal score as shown on table S4 in the supplementary document

### *G. Coding Framework Used in Thematic Synthesis*

An analysis of the coding framework identifies four primary aspects associated with the way in which the reviewed studies deal with the issue of problem formulation.

Firstly, there are studies, such as those conducted by [4], [13], [14], indicating that effective problem formulation should involve identifying gaps, having a context, and being relevant for specific stakeholders. In other words, a good problem statement implies the existence of a clearly defined gap that is grounded in a certain context and relates to some particular group of stakeholders.

Secondly, the studies indicate several aspects that contribute to ineffective problem formulation. For instance, [1], [10], [11], [16] shows that topic confusion, lack of empirical grounds, and premature focus on solutions undermine the quality of a problem statement and its research potential. To be more precise, many researchers begin their inquiry with discussing some technological theme or suggested solution rather than formulating a problem.

Thirdly, there is an aspect concerning the methodological consistency of the problem formulation approach. In other words, the results of the coding procedure suggest that methodological mismatch is one of the crucial indicators of poor-quality research. As shown by [13], [15], inconsistency in defining a problem statement, setting goals, and developing research questions leads to a loss of validity and relevance.

Finally, it is important to note that problem structuring appears to be another key issue associated with problem formulations. According to [1], [13], structuring contributes to increasing the methodological strength of a problem statement and promoting a more consistent research framework. Consequently, it becomes clear that a good problem statement formulation should include the presence of an empirical foundation, context, stakeholders, methodological consistency, and structuring. All these factors were taken into account while developing the PSFM. Supplementary Table S5 shows the coding framework that was utilised in the study

### *H. Data synthesis (Thematic Analysis)*

Due to the presence of considerable methodological diversity among included studies in terms of orientation, disciplines, and aims, a thematic analysis was selected for use in place of statistical meta-analysis. Thematic analysis was thought to be the most suitable technique for recognizing the common patterns, practices, and weaknesses related to problem statement formulations in computing studies. The data synthesis involved using an iterative analysis framework that followed three major coding stages, namely open coding, axial coding, and theme development. The first stage was the Open Coding. In this stage, each included study was read carefully to pinpoint significant text extracts related to problem statement formulation. In order to extract such codes as research gaps, vague problem statement formulation, problem-articulation quality, stakeholder involvement, technology-related limitations, inductive descriptive coding was used. Examples of open codes included problem identification, vague problem articulation, topic-problem ambiguity, methodology-related problems, relevance to stakeholders, need for empiricism, contextualization, premature problem-solving focus, problem statement quality, limitations of the technology, computing field-related challenges. Two independent reviewers engaged in coding in order to improve its reliability. Any discrepancies in codes were discussed until consensus was reached or changes in their definitions were made.

The second stage is the Axial Coding and Category Development. Following open coding, related codes were grouped into broader categories according to conceptual and methodological proximity. This stage served to discover relations among codes and to organize them into more general concepts and ideas. Main categories involved definition and conceptualization of problem statements, existing formulation frameworks and models, recurring weaknesses identified in literature, good practices in formulation, disciplinary distinctions in computing fields, computing-related methodological issues, and consistency in problem statements and design. Thus, the main goal of axial coding was to find out recurring relationships among codes.

The third stage was the Theme Development and Interpretive Synthesis. This stage comprised interpretation of coded data into major themes that were conceptually and methodologically consistent and relevant to the four research questions. Theme development focused on discovering common methodological patterns and practices, weaknesses, and differences. The findings of this stage helped develop the Problem Statement Formulation Model (PSFM) by pinpointing key components necessary for proper problem formulation in computing. In order to ensure conceptual coherence throughout the entire analysis process, interpretive syntheses were cross-validated continuously. An overview of this synthesis stage can be found in Supplementary Table S6.

## III. SUMMARY OF RESULTS

This study identified and synthesised evidence from 16 studies that answered the formulated research questions. The studies addressed the formulation, articulation and conceptualisation of research problem statements in the computing field. The studies included comprised of conceptual discussions, empirical papers, framework development studies and discipline-specific research method papers. Results from all studies point out to the importance of statement of the problem but however state that its formulation remain inconsistent, fragmented and regularly inadequately tailored to the realities of computing research. A thorough synthesis of the reviewed literature focusing on the formulation of problem statements is presented in Supplementary Table S6. Due to space limitations in the main manuscript, this detailed table is given as supplementary material. The table thoroughly maps each selected study to the formulated four research questions, capturing how problem statements are defined, the frameworks or models employed, recurring patterns, strengths and weaknesses identified across the literature, and the implications for improving problem statement formulation in computing research.

### A. Characteristics of included studies

The final samples included 16 papers that covered several areas of computing such as information systems [2], software engineering [15] , computer science [5] , educational technologies [1] , cyber security, artificial intelligence, and research within theoretical computing [4], [9], [10], [11], [13], [16]. The years of publication varied from 2019 to 2026 which indicated that researchers become increasingly interested in methodological quality, especially in formulating research problems in the current computing context. In terms of methodology, the reviewed studies showed high methodological diversity. Specifically, about 44% (n=7) of all studies reviewed were theoretical research that provided guidance for problem formulation, whereas 37.5% (n=6) were empirical studies, highlighting the problem formulation in practice. Finally, 18.5% (n=3) of all papers considered framework or model building as an approach to problem articulation. This proportion implies that although problem statement formulation is highly conceptual, attempts have been made to make this process more tangible. Geographically, the selected papers demonstrated significant geographic diversity which suggests that problem statement formulation poses challenges regardless of the country and discipline. Still, methodological diversity remained relevant as conceptual approaches to problem formulation varied greatly.

### B. Temporal Distribution and Methodological Trends of Included Studies

Upon analysis of publication years, there appears to be a gradual increase in the amount of focus given to scholarly problem formulations in the computing field between 2014 and 2026. In addition, most of the studies covered here were published after 2021. The observed trend shows that there is increased appreciation of methodological rigor, research design, and proposal preparation in the face of dynamic and evolving computing environments. Previous researches have generally been focused on providing conceptual guidance on formulating research problems. More recent researches have become increasingly focused on ensuring that the problem statement process is methodologically appropriate, relevant to stakeholders, justified by evidence, and formulated within a computing context. Methodological progression can be seen throughout the literature reviewed here as well. Older publications tended to provide general guidelines on scholarly writings while newer publications tend to emphasize on problem formulation methods and contextualization in relation to technological contexts like artificial intelligence and cyber security among others.

### C. How statement of the problem is defined in computing (RQ1)

Across the literature reviewed, the problem statement is understood to be a structured description of some of an unresolved question, knowledge gap, inefficiency, contradiction, or technological limitation that requires systematic examination [1], [2], [15]. However, significant differences emerge across disciplines in terms of how researchers formulate such statements in relation to their particular domain. In the field of Information Systems, research questions usually revolve around organization inefficiencies, obstacles to technology adoption and implementation, problems related to decision-making and digital transformation difficulties [2]. Such papers tend to stress socio-technical alignment and relevancy for stakeholders. In Software Engineering research, problem statements often relate to performance limitations of software systems, maintainability issues, software bugs, testing inefficiency, scalability problems, and difficulties in requirements engineering [3],[15] . In such research, problems are usually defined based on technical shortcomings of software. The most typical focus of problem statements in Artificial Intelligence and machine learning research relates to limitations in prediction, issues of explainability, scalability, ethics, and biases that come with intelligent software [3],[10] . Papers in such areas increasingly focus on trustworthiness of algorithms. Problems formulated by cyber security research tend to be related to vulnerabilities, difficulties in detecting threats, human factor risks, security awareness, and resilience to cyber-attacks [2],[15] . Meanwhile, Human Computer Interaction (HCI) research is known to formulate its problem statements in relation to usability limitations, accessibility constraints, human cognition, engagement, and interface issues [2],[15]. Despite the above-discussed differences in approaches, analysis of literature shows that there are five key elements in effective problem statements namely gap identification, contextualization of the problem, justification for its existence (either empirical or theoretical), articulation of significance, and relation to systematic investigation.

### D. Existing Models and Frameworks used in problem formulation (RQ2)

The study identified several recurring approaches that are utilised to formulate problem statements. Of all the models identified, no single model dominated the literature reviewed

*Gap-based formulation models*

Many studies depended on the traditional research gap model where researchers find what existing literature has not sufficiently explained, solved or tested [1], [2], [14]. This approach is mainly utilized in Information Systems, Human Computer Interaction, and AI-related studies. While very effective for academic positioning, there is a risky of coming up with superficial claims of novelty without adequately demonstrating the practical relevance of the gap.

*Needs-based or contextual models*

Several studies formulated problems after observing real-world needs for example institutional inefficiency, user frustration, and poor service delivery and security incidents. Robust studies will clearly link artefact development to a validated organisational or technical problem. Weak studies will just propose building a tool without sufficiently establishing the problem environment [3], [4], [9], [16] .

*Artefact-oriented models*

In design-oriented studies, the problem statement is often formulated to improve or replace an existing system, process or artefact. A robust study will need to link artefact development to a validated organizational or technical problem. On the other hand, weak studies just propose building a tool without adequately establishing the problem environment [11], [9], [16]

*Stakeholder-Informed models and Structured Multi-stage Models*

A smaller subset of reviewed studies highlighted that interviews, surveys, consultations and participatory methods can be utilised to identify organisational challenges before coming up with a research problem [2][15] . On Structured and Multi-stage models, few methodological papers proposed staged approaches that involved problem identification, evidence gathering, delimitation, significance justification and articulation. These models promote good research design practice but were not broadly adopted in computing field. Overall, evidence obtained suggests that computing researchers utilise multiple informal approaches, but systematic problem formulation frameworks remain underutilised. Theme-based analysis suggests that the formulation approach based on gap constitutes the commonest approach accounting for more than half of the number of studies covered in this review (n = 8). The contextual needs-based approaches occur in 25% of studies covered (n = 4), mainly in information system and educational computing literature. Artefacts approaches make up 19% (n = 3) of all the literature analysed and are mostly found among design oriented and software engineering literature. It is worth noting that only one study accounts for 6% of all literature analysed, which provides a structured problem formulation approach.

## E. *Recurring weaknesses in published studies (RQ3)*

Recurrent gaps identified in the analysis included topic–problem confusion, solution bias, insufficient empirical justification, insufficient context, and insufficient methodological alignment [9], [10], [11], [13],[15],[16]. Topic-problem confusion occurred in about 62.5% of examined studies (n = 10), with broad technical topics for example artificial intelligence, cyber security and digital transformation being framed as research problems. Prematurely oriented toward solution formulation, about 56% of analysed studies (n = 9) presented ideas for artefacts, frameworks, machine learning algorithms, or other applications before providing a thorough analysis of the underlying problem and its justification [9], [10], [11], [13],[15],[16].Insufficient empirical justification was evident in roughly 50% of analysed studies (n = 8), with the researchers claiming the existence of an issue based on lack of data from institutions, stakeholder input, performance metrics, or contradictory statements made in previous literature. Poor contextualization was also common in about 44% of evaluated studies (n = 7), as research problems lacked the description of organizations, users, institutions, and technical environment associated with the problems under investigation. Lastly, weak methodological alignment between problem formulation and study design could be found in about 38% of examined studies (n = 6), with causative explanations examined using descriptive research methods, optimization claims without benchmarks, and usability problems not analysed via user-centred approaches.

However, good research practices that were recurrently used in well-constructed research papers included clear gap identification, proper justification, contextual specifics, proper methodological alignment, and connections between problem statements, research goals, and hypotheses [2], [4], [13], [14]. Collectively, these results suggest that successful computing research is heavily reliant on comprehensive methodologies employed at the beginning of problem formulation.

## F. *Characteristics of High-Quality Problem Statement Formulation*

From analysis of more comprehensive studies, the following recurring best practices associated with the formation of the problem statements in computing research were identified. Firstly, robust studies always support research problems by empirical data, clearly distinguish between topic and researchable problem, put the problem into context by showing its relevance within a particular technological or organizational setting, and have a clear alignment between the problem statement, aims, methodology, and contributions of the study [1], [9], [10] [14], [15]. Secondly, robust studies incorporate aspects of stakeholders' input, organizational environment, and context into problem definition. In contrast to studies that first propose technological solutions to a problem, robust studies always first show that the problem exists and is worthy of attention before proposing any solution [1], [2], [11], [15], [16].

As such, the consistent strengths and weaknesses found within the methodological approach used in the analysed literature became the basis upon which the Problem Statement Formulation Model (PSFM) was built. As such, this model did not arise as a theoretical construct; rather, the model emerged from the actual problems encountered within various fields of computing through repeated observation.

### G. Synthesis leading to the proposed Problem Statement formulation Model (PSFM)

The thematic synthesis of reviewed studies shows that effective statements of the problem in computing research are not formulated based on intuition but rather through structured progression of interrelated elements. Several literatures emphasised the need to understand the broader technological, organizational and contextual environment where the study is positioned. Problem statements become significant when grounded in real operational settings such as industry, universities or healthcare rather than abstract technological trends [2], [5], [15]. This means that computing researchers should first demonstrate awareness of surrounding context, policy, realities, stakeholders and infrastructure limitations before narrowing to a specific problem.

Secondly, literature reviewed highlighted that credible research problems should be drawn from an identifiable and evidence –supported gap. Several studies argued that early researchers often confuse a topic area with a problem, leading to the formulation of statements that just describe fashionable technologies such as cyber security, Artificial Intelligence, block chain or Human Computer Interaction without showing what is unresolved or deficient [3], [10], [11]. Robust studies on the other hand rely on empirical evidence, contradictions in literature, prior findings, or unmet user needs to justify the existence of a research gap [4], [13]. This study therefore noted that gap identification is important to robust problem formulation.

Thirdly, once the gap is identified, it should be transformed into a clear and researchable problem. Several frameworks from the reviewed literature noted that raw issues should be converted into analytically bounded questions with defined variables, systems, actors and processes [1], [6], [16]. In computing research, this often means translating broad concerns such as low student engagement, poor system adoption or weak cyber security preparedness into measurable and investigative research problems. If studies lack this structure, they risk remaining descriptive rather than scientific.

Fourthly, synthesis done also demonstrated that robust problem statements highlight significance and expected contribution. Computing researchers need to justify why the problem matters practically, theoretically, socially and technologically. Literature that focused on research design and doctoral writing constantly stressed the need for a problem statement to show the value of solving the identified issue, whether through new knowledge, cost reduction, improved performance, policy relevance or user satisfaction [9], [12], [13]. In computing research, contribution can include algorithmic improvement, system innovation or process automation.

Fifthly, literature also indicated the need for the final wording of the problem statement to be explicit, concise and aligned to research questions, objectives and methodology. Poor alignment happens when a problem statement is too broad, while the objectives are narrow, or when the methods proposed do not realistically investigate the stated issue. Literature of methodology emphasised the need for coherence between the problem statements and overall research [5], [7], [15]. The statement of the problem should function as a logical bridge connecting the research gape, objectives and selected methods.

Collectively, the five recurring elements highlighted in reviewed literature informed the development of the Problem Statement Formulation Model (PSFM). The model was not developed in isolation but synthesised from patterns noted from methodological, conceptual and empirical studies on research problem formulation. The PSFM provides a structured pathway for computing researchers to craft precise, evidence-based ad researchable statement of the problem.

### H. Development and Validation Logic of the Proposed Problem Statement Formulation Model (PSFM)

The formulated PSFM is based on the thematic synthesis of conceptual, methodological, and empirical patterns discovered in the analysed literature. It means that instead of being theoretically formulated as a pure hypothesis, PSFM is an outcome of methodological strength and weakness observations, as well as of empirical evidence-based formulation practices typical for thorough computing research. According to the review findings, current problem formulations often focus on one specific aspect related to the formulation process, such as research gaps, stakeholders, contextualization, or problems [1], [2], [4], [13], [14]. Nevertheless, there does not exist a formulation framework that would successfully integrate all these elements in a methodological process suitable for the computing environment. Thus, the PSFM has been created with the aim of overcoming the identified methodological gap and formulating a clear and evidence-based formulation approach, which takes into consideration the computing specifics.

The Problem Statement Formulation Model (PSFM) was developed using thematic synthesis of recurring methodological strengths and weaknesses observed in the reviewed literature. In contrast to other available models which mainly focus on identifying gaps, engaging stakeholders, or articulating problems, PSFM provides an organized and integrated computing-specific model for developing research problems.

The proposed model improves current methodological practices by introducing a set of five interrelated formulation stages namely Context analysis, Evidence-based gap identification, Problem structuring, Significance and justification and Problem statement articulation. Importantly, the proposed model directly addresses the deficiencies found through the literature review, including vagueness in articulation, inappropriate methodology, weak context, and premature solutions. As such, the model constitutes a possibly transferable framework for guiding postgraduate supervision, proposal writing, doctoral studies, and scholarly publication in computing-related fields.

### I. Explanation of the proposed Problem Statement Formulation Model (PSFM)

The proposed Problem Statement Formulation Model (PSFM) includes five consecutive and interdependent stages that tackle repeated weaknesses found in the review of literature. The first stage is the Contextualization of Computing Problems. At this stage the researcher is expected to establish the computing environment in which the problem is situated by determining such factors as technologies, institutional realities, stakeholder contexts. This stage is developed in order to address a weakness commonly found in weak computing problems which is the failure to appropriately contextualize the problem. In other words, when studying cyber security issues, artificial intelligence, software engineering for example, the researcher is supposed to determine relevant technological, stakeholder, and institutional environments prior to formulating a research problem. The second stage is the Evidence-Based Gap Identification. At this stage, researchers are expected to identify an unresolved issue using evidence such as literature, empirical studies, stakeholder views, and contradictions. The weakness addressed in this stage is related to such issues as topic-problem confusion and solution orientation. Furthermore, the third stage is the Problem Formulation. At this stage, the problem becomes formulated by researchers through articulating its scope, stakeholders, context, boundaries, and construct definition. This process is very important because it minimizes ambiguity in problem formulation. The fourth stage is the Significance and Rationale. Under this stage, researchers have to articulate a rationale for studying the problem by explaining its significance in terms of technological, theoretical, practical, institutional, or any other aspects. As shown in the review, most weak problems had no justifications provided at all. The fifth and last stage is Problem Statement Articulation. This is the final stage of PSFM when a concise, well-articulated, and evidence-based problem statement is formulated by the researcher. Figure S2 in the supplementary document shows the proposed PSFM diagram.

### J. Practical Application of PSFM in Computing Research

The proposed PSFM may be practically implemented in computing research proposal development through a staged formulation process.

TABLE 1
PSFM STAGES AND PRACTICAL RESEARCH ACTIVITY

| Practical Research Activity | PSFM Stage |
|---|---|
| Define technological domain and context | Context Exploration |
| Conduct literature review and identify unresolved issues | Evidence-Based Gap Identification |
| Define measurable research problem | Problem Structuring |
| Explain contribution and importance | Significance and Justification |
| Write final problem statement | Problem Statement Articulation |

### K. Comparison of models with proposed PSFM

The study did a comparative synthesis of existing models and frameworks on research problem formulation, alongside the proposed Problem Statement Formulation Model (PSFM) as shown on Supplementary Table S7. Due to limitations in space on the main manuscript, this detailed comparison is provided as supplementary material. The table shows key authors, their corresponding models or frameworks, core components, contributions to computing research, as well as identified strengths and limitations. The study further compares each framework with the proposed PSFM, showing how the model integrates and extends prior approaches by providing a structured, evidence-driven, and computing-specific formulation process. This supplementary table gives a consolidated view of the theoretical foundations informing the development of the PSFM and supports the comparative analysis discussed in the main text.

## IV. PRACTICAL EXAMPLES OF GOOD AND POOR PROBLEM STATEMENTS IN COMPUTING RESEARCH

A frequent finding in this literature review indicates that many postgraduate students, beginners, and young computing scholars understand the significance of problem statement yet find themselves unable to produce a high-quality researchable formulation because of the lack of methodological rigour [1], [2], [4]. A poor problem statement in reviewed computing literature often results from confusing research topics, technological trends, development intentions, and a researchable problem [1], [2], [4], [13], [14].

To make the conclusions of this analysis more applicable for practical use, several examples of both weak and robust problem statements are provided in this section to illustrate some key differences between the two types of problem statements. It is important to clarify that this part does not propose any single way to write an effective problem statement but demonstrates how to differentiate between an academic research problem, an interesting topic to study, technological intentions and ideas, and solution proposal.
Based on the thematic synthesis, robust computing problem statements can be characterised by five features namely a specific problem or a research gap, contextual relevance, justification or rationale, statement of significance, connection to the objectives and methodology [4], [13], [14]. In turn, weak problem statements are often overly broad, have no context, orientated towards the solutions to the problem, have little evidence, and are unclear about methodology [1], [2], [4], [13], [14].

### A. Example 1: Artificial Intelligence in higher education

A methodologically flawed problem statement can read "*Higher educational institutions should use artificial intelligence in order to enhance teaching and learning processes.*" This statement is not methodologically sound since it reflects technological preferences rather than a problem worth investigating. The statement does not indicate the setting, the impacted individuals, and the existence of an unsolved issue, possible outcomes, and the gap in existing literature. Additionally, the problem statement implies an already existing solution to an educational issue that has not been well-defined yet. A stronger problem statement can read as follows "*Some higher education institutions that operate under resource constraints struggle with delayed academic feedback, low levels of personalized tutoring, and minimal student involvement because of heavy lecturers' workloads within large undergraduate classrooms. In spite of the rising usage of intelligent technologies, little is known about whether tutoring supported by AI enhances turnaround of feedback, learning engagement, and student satisfaction within the higher education domain.*"

### B. *Example 2: Cyber security in organisations*

A weak problem statement in the field of cyber security would read "*Cyber security is an important problem for organizations.*" This statement is too general and vague since it fails to identify any specific cyber security issue while simultaneously failing to identify an organizational setting, target users, or the empirical necessity for research. A stronger problem statement would read "*Today, many small and medium-sized organizations are increasingly using cloud computing technologies, but most of them lack structured cyber security awareness programs. Therefore, they repeatedly become victims of phishing attacks, and human-factor problems contribute significantly to organizational security risks. However, little is known about what measures should be taken to mitigate phishing threats in terms of employee training.*"

This problem statement is comprehensive because it identifies a specific cyber security problem, outlines the organizational setting, shows the empirical importance, reveals a clear gap, and creates methodological coherence.

### C. *Example 3: Software Engineering*

An inadequate problem statement would read "A need exists for improved software system performance." This statement lacks clarity and does not outline which software environment, which users, what aspect of performance and on what basis investigation should take place. An improved problem statement would read "*Agile software development projects often face delays in identifying defects in the course of work due to deficiencies of manual testing methods. While automated testing solutions have become increasingly popular in recent years, there is little proof of their efficiency in reducing defect detection time.*" This statement is robust because it establishes the context, points out inefficiency, shows the need for investigation, and avoids assumptions about technology.

### D. *Example 4: Human-Computer Interaction (HCI)*

Weak Problem Statement in the field of HCI would read "*Applications must become more user-friendly.*" This problem statement does not contain any measures, specific users who would benefit from it, situational context, or scientific evidence backing the problem's usability concerns. On the other hand a strong problem statement would read "*Users older than 65 years face numerous problems while interacting with mobile health apps because of poor interface and usability issues. However, there is no solid evidence on which interface design rules can improve user interaction with such applications for the specified age category.*" This problem statement is robust because it highlights the target user category, outlines the usability problem, gives context to the problem, and reveals an existing research gap.

### E. *Example 5: Generative Artificial Intelligence and Large Language Models*

An ineffective problem statement in this field would read "*The use of ChatGPT will enhance research in universities*." This is a technologically driven statement that does not reflect any researchable problem. It presumes the utility of the technology but does not identify an established challenge or need. An effective problem statement would read "*There is growing concern over the role played by the increasing use of artificial intelligence generators and large language models in terms of research integrity, reliance on AI, and critical thinking among postgraduate computing students. However, there is a lack of evidence-based studies about how AI assistance in research writing impacts the definition of the research problem.*" This statement is robust because it is measurable, highlights context in computing and shows methodological importance

### F. *Example 6: Student Research Proposal Example*

One common weakness highlighted in postgraduate proposals is the formulation of a project title as the problem statement. Such a statement could read "*Design and development of an online attendance management system"*. This statement simply describes a deliverable rather than a research problem. A robust version of this statement can read "Several *higher education institutions are still depended on manual attendance systems that are susceptible to fraud, inaccurate records and delayed reporting. However, there is inadequate evidence on whether low-cost biometric-powered attendance systems can advance reliability and administrative efficiency in resource-constrained institutions"*. This robust statement changes a development idea into a researchable problem by introducing context, evidence, consequences, and a knowledge gap [13], [16].

Collectively, all the above cases show how important it is for a proper problem statement formulation to make sure the evolution of research problems is going through various levels, including from broader topics related to technology to more analytically defined, supported by evidence and context-specific problems. At the same time, it should be noted that the examples above are consistent with the five stages of the proposed Problem Statement Formulation Model (PSFM).

## IV. DISCUSSION

The purpose of this systematic review is to conduct a critical analysis of how problem formulations are conceived, developed, and employed within the computing field. This systematic review reveals that, while problem statement formulation is acknowledged to be the key element in conducting quality research, methodology used within computing research is diverse and inadequately linked to the nature of research carried out within computing. However, the most significant insight from the review is that problem formulation issues have a much more serious dimension than academic concerns about poor-quality writing and relate to methodological issues that can influence the coherence of the research, its validity, and impact. Computing research often involves engineering artifact development, empirical study, algorithms, and complex organizational structures. Badly formulated problem statements may seriously impair the progress of research within the field.

Regarding the first research question, the results have shown both convergence and divergence regarding the way in which a problem statement is understood in the field of computing. Most of the reviewed literature defined a problem statement as a research gap, unresolved problem, inefficiency, or contradiction in need of systematic examination [1], [2], [15]. There were differences among disciplines in how each of the constructs was operationalized, implying the existence of distinct epistemological frameworks among computing disciplines. Specifically, software engineering and computer science literature tend to understand problems based on objective technical problems or inefficiencies, while information systems and HCI literature consider the social dimension and users' behavior in the context of computing problems [1], [2], [15]. The literature on artificial intelligence tends to frame problems using issues related to the ethical concerns surrounding intelligent technologies such as the fairness and explainability of artificial intelligence algorithms [1], [15]. These results imply that problem statements in computing cannot be addressed through universal guidance for writing research. Different approaches will be required by different computing disciplines.

With regard to the second research question, it can be deduced that while there are various models and approaches used to formulate problem statements, the use of these models and approaches in computing-related research is inconsistent and disparate in nature. Most existing models tend to focus on gap identification, evidential basis, relevance to stakeholders, or clear articulation; yet, only very few models are able to provide a more holistic method that would take into consideration the methodological challenges involved in computing-based research [1], [2], [13], [14]. This could partly explain the repeated shortcomings found in research articles. It should be noted that today's computing-based research involves not only technical experimentation but also socio-technological issues and technological changes, among others [1], [2], [4], [13], [14]. In such cases, models intended for other forms of research might fall short in facilitating effective problem statement formulation.

From the above analysis, it becomes clear that there are persistent gaps in the process of formulating a problem statement. One area in which these gaps have been persistently observed involves frequent confusion between the issue being addressed and the topic under discussion [9], [10], [16]. In this case, the use of computing technology topics such as artificial intelligence, cyber security, block chain technology, and digital transformation can be viewed as the problem itself instead of an issue within the broader context [1], [2], [4], [13], [14]. This approach might suggest increased pressure on computing researchers to discuss contemporary issues related to new technological developments before justifying the need for the proposed solutions. Equally, the key recurring elements identified from more methodologically sound research papers include the empirical justification of the problem at hand, its clear definition in the research context, proper scope of the research, and consistency of the problem statement with research aims and methodological choices.

*Theoretical Contribution of the study*

This paper offers an insight into computer science research methodology, providing a refined theory about the methodology of problem formulation from the generic guidelines for research problem formulation used in academic papers to a methodology process specific to the domain of computing. Unlike previous studies [3], [4], [13] which focus on the importance of concept clarity or simply identifying a research gap, the current review reveals that a proper problem formulation within the context of computing research is a result of the interaction between contextualization, evidence, methodology, technology, and relevance to stakeholders. Moreover, this paper offers a synthesis of the variations among disciplines in terms of problem formulation. Therefore, the paper argues that problem formulation in computing requires specialized advice for problem formulation due to its nature.

## V. RECOMMENDATIONS

Considering the results obtained from the systematic review, this article proposes several recommendations aimed at improving research problem statement formulation within computing research. Researchers in computing should adopt structured frameworks for problem formulation, rather than relying on intuitive or general technological interests when developing problem statements. The use of an evidence-based Problem Statement Formulation Model (PSFM), for example, may help to follow a systematic approach when formulating research problems.

One of the key implications of this systematic review relates to the need to differentiate between the notions of technological topic, research problem within the scope of computing research [9], [10], [11], [16]. Researchers tend to confuse broad thematic areas for example artificial intelligence, cyber security, cloud computing, and data analytics with specific problems that require further study. In addition, engineering purposes and target solutions within the area of software development are regarded as research problems. [9], [10], [11], [16] According to the findings of this systematic review, there is a consistent pattern of using topic description instead of analytical, evidence-based formulation of the problem. Hence, problem formulation in research training programs should be distinguished from topics, development objectives, and research problems within the scope of computing research [9], [11].

In addition, the identified problem formulation challenges point to the necessity to increase methodological consistency. Specifically, an effective problem statement should present a clear correlation between the stated problem, research aims, and research questions and used methods [4], [13], [15]. However, there are instances where researchers adopt methods that are not consistent with the problem under study and, hence, cannot contribute towards addressing the problem. Future research training and supervisory practices should pay greater attention to maintaining a consistent set of core components of the research problem.

Furthermore, it is essential to ensure evidence-based justification of the problem within a formulated statement. An effective problem statement should be based on empirical evidence, existing contradictions or gaps in the literature, inefficiency in practices and policies, user and stakeholder needs, and contextual realities [2], [4], [13], [14]. Many of the reviewed studies focused on problem resolution without prior demonstration of existence, significance, and nature of the problem. Thus, researchers need to refrain from stating technological solutions before justifying the relevance of the underlying problem [2], [4], [14].

As one of the recommendations emerging from the findings, the development of problem formulation training programs for computing studies should be emphasized. Universities and research organizations should offer problem formulation training as part of postgraduate research supervision, PhD research proposal development, courses in research methodology, and academic writing sessions. In general, computing research involves various technical, organizational, human, and socio-technical aspects, which makes computing studies significantly distinct from other disciplines in terms of research problems formulation [1], [9], [14], [15].

It should also be noted that the role of artificial intelligence in problem formulation will continue growing. In particular, large language models (LLMs) have become very popular tools in academic writing and can be helpful in research problem formulation [9], [10], [11]. Yet, it is important to use such models carefully and responsibly because the resulting problem statement has to be validated through evidence, literature, and contextual realities. Therefore, researchers should be mindful about AI's capabilities when formulating the research problem.

As the final step of this review, it is recommended to validate the proposed PSFM empirically. The model has been developed based on a systematic synthesis of the literature available in the public domain but however, it is necessary to verify the efficiency of PSFM as a practical tool. The process could involve applying PSFM to postgraduate proposals, doctoral research projects, computing-specific problem formulation trainings, and academic manuscript development.

## VI. CONCLUSION

The current study provides a systematic analysis of how research problem statements are conceptualized, formulated, and operationalized in computing literature based on synthesizing evidence from peer-reviewed computing-related methodological, conceptual, and empirical papers. It was found that even though the crucial role of good problem formulations in computational studies is generally acknowledged, the current approaches towards developing research problem statements lack consistency and methodological unity. Specifically, the paper revealed several recurring flaws, which included problem-topic confusion, premature solution-oriented framing, insufficient empirical grounding, poor contextualization, and methodological inconsistency. In turn, high-quality studies featured recurrent practices such as context-based research problem statements, evidence-based justification of gaps, methodological consistency, and alignment between problems, aims, and methods.

Importantly, the results show that different computing disciplines conceptualize their research problems in unique ways, meaning that generic methodological advice is unlikely to provide sufficient guidance for computing scholars. To address this limitation, a new research framework called the Problem Statement Formulation Model (PSFM), based on systematic synthesis of themes, was developed.Unlike the currently fragmented approaches to problem formulation, the proposed model is methodological in nature as it suggests a series of systematic steps in terms of exploring the context, identifying gaps, formulating problems, justifying significance, and articulating the research statement itself.

Furthermore, it should be noted that PSFM is still at a theoretical stage of development and lacks empirical validation. Thus, further research is required to test the efficacy of PSFM in practice through studying computing researchers' experiences in postgraduate proposal writing, supervision, and publication. Overall, it is expected that addressing the problem of research problem statements in the computing field will result in improved methodological approaches to research and increased rigor.This study therefore contributes both methodological synthesis and a practically applicable computing-specific formulation framework that can support future research quality improvement across different computing domains.

## REFERENCES


[1] M. Kaushik, P. Baligar, and G. Joshi, "Formulating An Engineering Design Problem: A Structured Approach," 2018.

[2] P. A. Nielsen and J. S. Persson, "Engaged problem formulation in IS research," *Communications of the Association for Information Systems*, vol. 38, no. 1, pp. 720–737, May 2019, doi: 10.17705/1CAIS.03835.

[3] M. Shoket, "Research Problem: Identification and Formulation: Mohd Shoket 512," *International Journal of Research (IJR)*, vol. 1, no. 4, 2014.

[4] A. Younas, A. Durante, and S. Fàbregues, "Understanding the Nature of and Identifying and Formulating 'Research Problems' in Mixed Methods Research," *J. Mix. Methods Res.*, vol. 18, no. 4, pp. 483–502, Oct. 2024, doi: 10.1177/15586898231191441.

[5] M. K. M. Nasution, M. Elveny, and R. Syah, "Research methodology for computer science," in *AIP Conference Proceedings*, American Institute of Physics Inc., May 2023. doi: 10.1063/5.0134511.

[6] B. Aishwarya Ravindra, "International Journal of Legal Science and Innovation Formulating a Research Problem," *International Journal of Legal Science and Innovation*, vol. 4, 2022, doi: 10.10000/IJLSI.111295.

[7] H. Emilio, M. Barrios, Á. Arrieta Hernández, and A. R. Escobar Brochero, "Practical Guide to Formulating the Title, Problem Statement and Research Question from a Qualitative Perspective," 2024. [Online]. Available: https://powertechjournal.comORCID:https://orcid.org/0000-0003-1880-6929ORCID:https://orcid.org/0000-0002-6083-4360

[8] D. A. Sanders and S. S. Mukhari, "Lecturers' perceptions of the influence of AI on a blended learning approach in a South African higher education institution," *Discover Education*, vol. 3, no. 1, Dec. 2024, doi: 10.1007/s44217-024-00235-2.

[9] S. Kehinde, "Writing a Statement of Research Problem," *SAR Journal - Science and Research*, pp. 93–98, Mar. 2025, doi: 10.18421/sar81-12.

[10] W. Badke, "Frustrations of Formulating Research Problem Statements," Online Searcher, vol. 47, no. 3, pp. 10–13, 2023.

[11] A. Gidado and U. Bappi, "Statement of the Problem: An Examination of the Common Pitfalls and the Way Forward," Nigerian Journal of Public Sector Management, vol. 7, no. 2, 2024.

[12] S. Parathasarathy, A. Samantaray, and D. Jain, "A well-formulated research question: The foundation stone of good research," Apr. 01, 2023, *Wolters Kluwer Medknow Publications*. doi: 10.4103/ija.ija_226_23.

[13] A. Ali and S. Pandya, "A four stage framework for the development of a research problem statement in doctoral dissertations," *International Journal of Doctoral Studies*, vol. 16, pp. 469–485, 2021, doi: 10.28945/4839.

[14] A. Sauve-Ciencewicki *et al.*, "A simple problem formulation framework to create the right solution to the right problem," Feb. 01, 2019, *Academic Press Inc.* doi: 10.1016/j.yrtph.2018.11.015.

[15] I. Sanders, C. Pilkington, and L. Pretorius, "Making research methodologies in theoretical computing explicit," *South African Computer Journal*, vol. 34, no. 1, pp. 192–216, Jul. 2022, doi: 10.18489/sacj.v34i1.881.

[16] E. O. Jonathan, "Research Problem Formulation Guide," *International Journal of Advanced Academic Research* |, vol. 10, no. 5, pp. 2488–9849, 2024, doi: 10.5281/zenodo.11190572.