



A Needs Analysis of PBL–STEAM–Aul-Based Scientific Writing Instruction

Dewi Lestari

Universitas Lampung,
Universitas Baturaja,
INDONESIA

Abdurrahman*

Universitas Lampung,
INDONESIA

Albet Maydiantoro

Universitas Lampung,
INDONESIA

Budi Kadaryanto

Universitas Lampung,
INDONESIA

Bambang Setiyadi

Universitas Lampung,
INDONESIA

Article Info

Article history:

Received: May 5, 2026

Revised: July 2, 2026

Accepted: August 22, 2026

Keywords:

Academic Writing;
Augmented Intelligence;
Instructional Materials;
Problem-Based Learning;
STEAM.

Abstract

Scientific article writing is a significant skill for university students because it supports critical thinking, academic communication, and scholarly knowledge development. However, students often struggle to identify research problems, develop ideas, build evidence-based arguments, structure articles, and revise academic texts. Existing instruction and materials are not always sufficiently structured, interdisciplinary, interactive, or supportive of responsible artificial intelligence use. This study aims to analyse university students' needs for instructional models and materials for scientific article writing through Problem-Based Learning (PBL), STEAM, and Augmented Intelligence (Aul). We used a descriptive quantitative approach through a needs-analysis survey of 281 students from 12 study programmes. We collected data using a questionnaire addressing learning conditions, PBL, STEAM, Aul, scientific-writing skills, instructional-material needs, and preferred material formats. We analysed the data using descriptive statistics and frequency analysis in SPSS. The findings showed a high perceived need for the PBL–STEAM–Aul instructional model ($M = 4.033$) and instructional materials ($M = 4.054$). Participants most preferred step-by-step scientific-writing guidance and interactive e-modules. These findings provide empirically grounded design specifications for integrating problem orientation, interdisciplinary exploration, human-centred intelligent assistance, feedback, and structured revision into scientific-writing instruction.

To cite this article: Lestari, D., Abdurrahman, Maydiantoro, A., Kadaryanto, B., & Setiyadi, B. (2026). A Needs Analysis of PBL–STEAM–Aul-Based Scientific Writing Instruction, 6(3), 135-147. <https://doi.org/10.58524/oler.v6i3.1304>

INTRODUCTION

Scientific article writing is increasingly important in higher education because students are expected not only to understand disciplinary knowledge but also to communicate research-based knowledge through academically credible texts. However, evidence from higher education contexts indicates a persistent gap between these expectations and students' ability to manage the scientific writing process. Studies involving university students have identified difficulties across several interconnected stages, including developing and delimiting ideas, formulating research problems, organizing arguments, selecting and integrating sources, using appropriate academic conventions, and revising written texts (Alkhabra et al., 2023; How & Hung, 2019; Kuo, 2025; Nindiasari et al., 2024). These difficulties are interconnected rather than merely linguistic, indicating the need for instructional support that guides students across the scientific-writing process.

* Corresponding Author

Abdurrahman, Universitas Lampung, INDONESIA ✉ abdurrahman.1968@fkip.unila.ac.id

These empirical problems matter because writing scientific articles is a composite academic competence, not a single language skill. It requires writers to identify a researchable problem and justify its significance (Fang et al., 2026), make arguable claims and connect them logically to evidence (Ratnakaram et al., 2025), contrast and integrate previous studies instead of merely listing them (Jesionkowska et al., 2020), describe methods and findings clearly, and communicate disciplinary knowledge according to the rhetorical and ethical conventions of a scholarly community (Tian, 2025). For example, a poorly articulated problem leads to an unfocused literature review, poor choice of evidence, and an argument that is difficult to support. Thus, instruction needs to teach scientific writing as a unified process of inquiry, reasoning, composition, evaluation, and revision.

This competence is increasingly important as higher education expectations change, with students increasingly involved in research activities and expected to communicate the outcomes of academic inquiry in formal scholarly formats. In Indonesia, current higher education standards position students as participants in research under academic supervision and require institutions to establish provisions for disseminating research outputs. At the course level, Li et al. (2025) documented an academic-writing course involving 307 Indonesian undergraduates in which students were expected to complete an extended project such as a research proposal, journal article, or academic essay. The gap between these expectations and students' demonstrated difficulties creates a clear pedagogical need for structured and sustained writing support.

These interconnected difficulties also highlight the potential role of intelligent technologies in providing timely support for generating and refining ideas, organizing arguments, evaluating evidence, checking textual coherence, and revising drafts. Generative artificial intelligence can provide support for several of these activities by producing explanations, suggesting alternative formulations, offering feedback, and assisting with idea exploration (Mulianah et al., 2025). However, these capabilities also create pedagogical risks. AI-generated information may be inaccurate or insufficiently aligned with disciplinary and assignment requirements. At the same time, overreliance on generated text may reduce students' engagement in reasoning and raise concerns about authorship and academic integrity (Ayanwale & Omeh, 2026). Therefore, the instructional issue is not whether AI should replace students' writing processes, but how intelligent technologies can extend students' cognitive activities while preserving their responsibility for evidence evaluation, reasoning, decision-making, and authorship (Syukur et al., 2024).

Augmented Intelligence (Aul) is a human-centered design orientation in which machine capabilities are deliberately combined with human judgement to extend, not replace, cognition and agency. Human-centered AI scholarship emphasises meaningful human control, stakeholder participation, transparency, safety, and a proper balance between automation and decision-making (Jaramillo-Fierro et al., 2026). In scientific writing, this orientation means using AI to support reflection, formative feedback, and revision while keeping substantive academic judgments under student control. A pedagogical framework is therefore needed to organize when and why to use intelligent support within the learning process. Problem-Based Learning (PBL) is relevant to this requirement because it organizes learning around authentic problems and guides students through inquiry, evidence gathering, explanation, and reflection. In this study, PBL therefore functions as the instructional structure within which STEAM-oriented inquiry and human-centered Aul support can be integrated.

Authentic problems can guide students to delimit topics and formulate research questions; self-directed inquiry requires them to locate and evaluate literature; discussion helps them examine alternative interpretations; and reflection and feedback support revision of both reasoning and text. Evidence from higher education research associates PBL with critical thinking, problem solving, self-directed learning, and knowledge application, while writing-oriented studies indicate that its benefits depend on scaffolding, examples, peer interaction, and iterative feedback (Yurnetti et al., 2020; Yuliyati et al., 2018). Thus, PBL can provide the instructional structure for scientific writing but requires writing-specific guidance.

STEAM provides a complementary interdisciplinary framework for scientific writing. Its integration can encourage students to connect disciplinary knowledge with technology-supported information management, systematic problem solving, creative communication, and quantitative or evidence-based reasoning, all of which are relevant to investigating problems and communicating complex knowledge across disciplinary boundaries. Related empirical studies also report that

STEAM-supported technology integration can strengthen students' problem-solving processes. However, most evidence comes from disciplinary learning contexts rather than scientific-writing instruction (Nindiasari et al., 2024). Previous STEAM research has reported benefits for creativity, communication, collaboration, and higher-order thinking, although direct evidence from university scientific-writing contexts remains limited (Stevi & Haryanto, 2020; Utaminingsih, 2021). Therefore, this study treats STEAM as an interdisciplinary lens to adapt to scientific-writing instruction rather than as an established writing method.

Previous research supports the relevance of PBL, STEAM, and AI-supported learning, but the evidence remains fragmented in three important respects. First, PBL research in higher education has primarily examined problem solving, critical thinking, and knowledge application, with less attention to the complete process of scientific article writing. Second, STEAM research has largely focused on interdisciplinary learning in science, technology, and engineering contexts, while its principles have rarely been operationalized as a framework for university scientific-writing instruction. Third, research on generative AI in education has increasingly examined feedback, productivity, inquiry, and ethical risks, but often discusses technological support separately from the pedagogical sequence through which students formulate problems, evaluate evidence, construct arguments, and revise texts. Consequently, the literature offers limited empirical guidance on how to coordinate these three functions within a single scientific-writing instructional design and how to translate students' perceived needs into concrete model and material specifications. Consequently, this study provides a needs-based empirical foundation for integrating PBL as the inquiry structure, STEAM as the interdisciplinary reasoning framework, and human-centered Aul as cognitive and formative support for scientific article writing across multiple academic disciplines. Accordingly, this study aims to analyze university students' needs for an instructional model and learning materials for scientific article writing through PBL, STEAM, and Augmented Intelligence.

METHOD

Research Design

This study employed a descriptive quantitative design using a needs-analysis survey. The study identified students' perceived needs, current learning conditions, expectations for instructional support, and preferences for instructional materials related to scientific article writing. The needs analysis was the analysis phase of a broader instructional development process and aimed to generate preliminary design specifications for a PBL-STEAM-Aul instructional model and its supporting materials (Amelia, 2023). Figure 1 presents the research procedure.

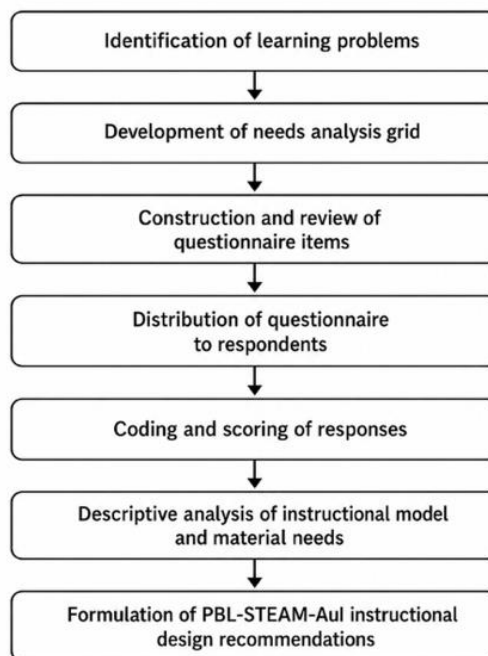


Figure 1. Research Procedure of the Needs Analysis Study

Participants and Sampling

The participants were 281 active university students from 12 study programmes who had prior experience with or exposure to scientific writing activities. The study used purposive sampling because it required respondents who could provide informed perceptions of scientific article writing instruction and identify their learning needs. Eligible participants were active students enrolled in the participating programmes, had experience or exposure to scientific writing activities, voluntarily agreed to participate, and completed all required questionnaire items. The respondents represented programmes in language education, informatics, agriculture, economics, business, communication, technology, and engineering. Because the sample was purposively selected rather than probability-based, the findings reflect a needs profile of the participating students rather than the broader university-student population. Table 1 presents the distribution of respondents by study program, covering students from various academic disciplines who participated in the needs analysis.

Table 1. Respondent Distribution by Study Program

No	Study Program	Frequency	Percentage
1	Indonesian Language and Literature Education	35	12.5%
2	Informatics	32	11.4%
3	Agribusiness	30	10.7%
4	Agrotechnology	30	10.7%
5	Management	28	10.0%
6	English Education	26	9.3%
7	Development Economics	23	8.2%
8	Digital Business	17	6.0%
9	Civil Engineering	17	6.0%
10	Accounting	15	5.3%
11	Communication Science	14	5.0%
12	Educational Technology	14	5.0%
Total		281	100%

Instrument

A researcher-developed questionnaire assessed students' perceived needs for the PBL–STEAM–AuI instructional model and supporting instructional materials. The items were developed from the literature on scientific article writing, PBL, STEAM, AuI, and instructional-material development and were organized into theoretically defined indicators. The questionnaire included 25 Likert-scale items on instructional-model needs and 20 on instructional-material needs, along with five multiple-choice items on preferred material formats and AuI-supported features. Before administration, five experts reviewed the questionnaire: two educational-evaluation lecturers, two language lecturers, and one learning lecturer. Experts assessed item relevance, clarity, representativeness, and language appropriateness. Content validity was quantified using Aiken's V. Because the instrument was developed as a multidimensional needs-analysis questionnaire, construct validity was not established through factor analysis in the present study and should be examined in subsequent research.

We examined internal consistency using Cronbach's Alpha as a supplementary reliability analysis. The analysis produced Alpha coefficients of 0.070 for the 25 instructional-model items, 0.083 for the 20 instructional-material items, and 0.099 for the combined 45 Likert-scale items. These coefficients are low and therefore do not provide strong evidence of internal consistency. The low coefficients should be interpreted in light of the questionnaire's multidimensional design, which aimed to map different aspects of students' perceived needs rather than measure a single homogeneous psychological construct. Nevertheless, the low coefficients constitute an important methodological limitation and indicate the need for further item refinement and dimension-specific reliability and construct-validation procedures in subsequent research. Table 2 presents the variables, indicators, and questionnaire items used in the needs analysis.

Table 2. Research Variables and Indicators

No	Variable	Indicator	Item Number
1	PBL-STEAM-AuI instructional model needs	Current learning condition, PBL, STEAM, AuI, scientific writing skills, need for model	1–25
2	Instructional material needs	Current material condition, content needs, scientific communication, AuI support, material expectations, material format	1–20

Data Analysis

Data were analysed using IBM SPSS Statistics. Frequencies and percentages described respondent characteristics and preferences for instructional-material formats. Means and standard deviations summarized the level and variability of students' perceived needs for each indicator. Likert responses were scored from 1 (strongly disagree) to 5 (strongly agree), and mean scores were interpreted using five categories: 1.00–1.80 (very low), 1.81–2.60 (low), 2.61–3.40 (moderate), 3.41–4.20 (high), and 4.21–5.00 (very high). Cronbach's Alpha was calculated as a supplementary assessment of internal consistency, with the results interpreted cautiously because the questionnaire consisted of multiple dimensions.

RESULTS AND DISCUSSION

This section presents the needs analysis findings in relation to the two research objectives. The results are reported in four parts: students' perceived needs for the PBL-STEAM-AuI instructional model, item-level model needs, students' needs for instructional materials, and preferences for instructional-material formats. The discussion then interprets the findings in relation to scientific-writing demands and the complementary roles of PBL, STEAM, and AuI.

Student Needs for the PBL-STEAM-AuI Learning Model

Table 3 presents the descriptive statistics of students' perceived needs for the PBL-STEAM-AuI instructional model across the assessed indicators.

Table 3. Descriptive Statistics of PBL-STEAM-AuI Instructional Model Needs

No	Indicator	N of Item Responses	Mean	Standard Deviation	Agreement	Category
1	Current learning conditions	1,405	3.894	1.029	69.8%	High
2	Problem-Based Learning	843	4.165	0.681	83.7%	High
3	STEAM integration	1,124	3.998	0.923	74.1%	High
4	Augmented Intelligence	1,405	4.104	0.771	80.9%	High
5	Scientific writing skills	1,124	3.887	0.997	69.7%	High
6	Need for instructional model	1,124	4.200	0.692	84.1%	High
	Overall mean	7,025	4.033	0.879	76.6%	High

Table 3 shows that the perceived need for the PBL-STEAM-AuI instructional model was high overall ($M = 4.033$, $SD = 0.879$). All six indicators were categorized as high. The highest mean was observed for the need for an instructional model ($M = 4.200$), followed by PBL ($M = 4.165$) and AuI ($M = 4.104$). STEAM integration ($M = 3.998$), current learning conditions ($M = 3.894$), and scientific-writing skills ($M = 3.887$) also fell within the high category. At the item level, the highest responses concerned the need for an innovative instructional model, the model's usefulness for scientific article writing, and the usefulness of AI for scientific writing.

Item-Level Analysis of PBL-STEAM-Aul Instructional Model Needs

SPSS descriptive analysis was also used to identify the highest and lowest item scores in the instructional model needs questionnaire. Table 4 shows the results.

Table 4. Highest and Lowest Item Mean Scores of Instructional Model Needs

Item	Statement Summary	Mean	Standard Deviation	Agreement
22	Need for an innovative instructional model	4.228	0.711	83.6%
25	The model helps students write scientific articles	4.217	0.691	84.7%
15	AI helps in scientific article writing	4.210	0.656	86.8%
23	Interest in problem-based and technology-supported learning	4.199	0.699	83.6%
6	PBL helps students understand the material	4.174	0.677	84.3%
20	Need for guidance in writing articles	3.786	1.094	64.4%
18	Difficulty writing complete scientific articles	3.811	1.094	63.3%
4	Difficulty composing background section	3.829	1.059	67.6%
11	Rarely experience STEAM-based learning	3.829	1.105	66.2%
17	AI has not been used optimally	3.833	1.020	68.3%

Table 4 presents the items with the highest and lowest mean scores for instructional-model needs. The highest-rated item was the need for an innovative instructional model ($M = 4.228$), followed by the perceived usefulness of the model for scientific article writing ($M = 4.217$) and the usefulness of AI for scientific article writing ($M = 4.210$). Other highly rated items concerned interest in problem-based and technology-supported learning and the usefulness of PBL for understanding learning materials. The lowest mean among the selected items was observed for the need for guidance in writing articles ($M = 3.786$), although it remained within the high category. Other relatively lower-rated items concerned difficulty in composing a complete scientific article and difficulty writing the background section. These results indicate variation in the perceived intensity of individual instructional needs.

Students' Needs for Teaching Materials

The second part of the questionnaire measured students' needs for instructional materials. The data were analyzed using SPSS descriptive statistics. Table 5 presents the results.

Table 5. Descriptive Statistics of Instructional Material Needs

No	Indicator	N of Item Responses	Mean	Standard Deviation	Agreement	Category
1	Current instructional-material conditions	1,124	3.605	1.031	60.1%	High
2	Content needs	1,405	4.183	0.696	83.3%	High
3	Scientific communication needs	843	4.149	0.683	83.0%	High
4	Augmented Intelligence support	1,405	4.164	0.713	81.5%	High
5	Expectations for instructional materials	843	4.155	0.693	82.6%	High
	Overall mean	5,620	4.054	0.808	78.1%	High

Table 5 shows that students' perceived need for instructional materials was high overall ($M = 4.054$, $SD = 0.808$). The highest indicator was content needs ($M = 4.183$), followed by Aul support ($M = 4.164$), scientific communication needs ($M = 4.149$), and expectations for instructional materials ($M = 4.155$). Current instructional-material conditions received the lowest mean ($M = 3.605$), although this indicator also remained within the high category. The content-needs items indicate strong demand for detailed scientific-writing concepts, complete article examples, article analysis, gradual writing exercises, and step-by-step guidance (Diani et al., 2018). The Aul-support indicator

also showed a high level of perceived need, particularly for assistance with understanding concepts, selecting topics, developing arguments, evaluating drafts, and receiving formative feedback.

Item-Level Analysis of Instructional Material Needs

Table 6 presents the highest and lowest item mean scores for students' perceived needs for instructional materials, based on the item-level descriptive analysis.

Table 6. Highest and Lowest Item Mean Scores of Instructional Material Needs

Item	Statement Summary	Mean	Standard Deviation	Agreement
8	Need for gradual writing practice	4.224	0.694	84.7%
6	Need for complete examples of scientific articles	4.214	0.715	82.9%
11	Need for scientific communication practice	4.199	0.678	85.1%
14	Need for assistance in determining writing topics	4.192	0.696	83.6%
19	Materials improve students' thinking ability	4.185	0.698	83.3%
4	Existing materials are interesting and helpful	3.495	1.025	55.2%
2	Existing materials are easy to understand	3.619	1.025	61.9%
1	Scientific writing materials are available	3.648	1.007	61.2%
3	Existing materials are systematically presented	3.658	1.061	62.3%
10	Need for written scientific communication guidance	4.125	0.699	81.1%

Table 6 shows that item 8, "I need gradual writing practice," had the highest mean score (4.224). This finding shows that students need instructional materials that guide them through the writing process step by step. Learning to write scientific articles comes not just from explanation, but from practice, examples, feedback, and revision. The second-highest item was the need for complete examples of scientific articles, with a mean score of 4.214. This suggests that students need exposure to strong scientific articles to learn structure, style, argumentation, citation, and academic conventions. Instructional materials should include annotated examples, article analysis tasks, and guided writing exercises. The lowest item concerned whether current materials are interesting and helpful, with a mean score of 3.495. This result reveals a practical gap between existing materials and students' expectations. Students need learning materials that are not only available but also engaging, interactive, structured, and directly connected to scientific article writing tasks (Hosna et al., 2026).

Frequency Analysis of Preferred Instructional Material Forms

The preferred forms of instructional materials were analyzed using SPSS (Analyze> Descriptive Statistics > Frequencies). Table 7 presents the results.

Table 7. Frequency Analysis of Preferred Instructional Material Forms

Aspect	Preferred Option	Frequency	Percentage
Media	Interactive e-module	105	37.4%
Media	Printed textbook/teaching book	75	26.7%
Media	Learning video	45	16.0%
Media	LMS/Google Classroom	35	12.5%
Media	Presentation slides	21	7.5%
Presentation	Practical step-by-step guidance	61	21.7%
Presentation	Examples and gradual exercises	57	20.3%
Presentation	Infographics and summaries	55	19.6%
Presentation	Question-answer and reflection	54	19.2%
Presentation	Case/project-based materials	54	19.2%
AuI Feature	Writing evaluation rubric	69	24.6%
AuI Feature	Article structure checking	61	21.7%
AuI Feature	AI prompt examples	53	18.9%
AuI Feature	Self-revision guide	50	17.8%

Aspect	Preferred Option	Frequency	Percentage
AuI Feature	AI-assisted feedback	48	17.1%
Access	Flexible access anytime	59	21.0%
Access	Smartphone access	58	20.6%
Access	Independent use	58	20.6%
Access	LMS integration	58	20.6%
Access	Offline download	48	17.1%

Among the media formats, the interactive e-module was most frequently selected (37.4%), followed by printed textbooks (26.7%). For presentation, practical step-by-step guidance was the most frequently selected option (21.7%). For AuI features, writing evaluation rubrics were selected most often (24.6%), followed by article-structure checking (21.7%). Flexible access anytime was the most frequently selected access preference (21.0%).

The reliability test was conducted in SPSS using Analyze > Scale > Reliability Analysis. Cronbach's Alpha was used to examine the questionnaire's internal consistency. The result showed that the Cronbach's Alpha value for the instructional model questionnaire was 0.070, the instructional material questionnaire was 0.083, and the overall questionnaire was 0.099. Table 8 presents the Cronbach's Alpha coefficients obtained for the instructional-model items, instructional-material items, and the combined Likert-scale items.

Table 8. Reliability Analysis Using Cronbach's Alpha

Instrument Component	Number of Items	Cronbach's Alpha	Interpretation
PBL-STEAM-AuI instructional model needs	25	0.070	Low internal consistency
Instructional material needs	20	0.083	Low internal consistency
Overall Likert items	45	0.099	Low internal consistency

The Cronbach's Alpha coefficients were low, as seen in Table 8. These numbers should be taken with a grain of salt, as the questionnaire was developed as a multidimensional needs-assessment tool rather than a single unidimensional psychological scale. The instrument measured several aspects, including current learning conditions, PBL, STEAM, AuI, scientific writing skills, needs of the instructional model, conditions of the instructional materials, content needs, scientific communication, and expectations of the instructional materials. Therefore, calculating a single Alpha coefficient across heterogeneous dimensions could underestimate the instrument's consistency. For this reason, the results were interpreted mainly using descriptive statistics and frequency analysis, which better aligned with mapping students' instructional needs.

Discussion

The high perceived need for PBL can be interpreted in relation to the procedural demands of scientific article writing. Students' reported difficulties include formulating research problems, developing ideas, selecting evidence, organizing arguments, and revising texts, all of which require inquiry rather than the reproduction of predetermined information. PBL provides a pedagogical structure that begins with an authentic problem and requires learners to identify what they know, determine what they need to investigate, evaluate evidence, develop explanations, and reflect on their solutions. This correspondence helps explain why PBL received a high perceived-need score in the present study. The finding is consistent with evidence that PBL can support critical thinking, inquiry, problem solving, and knowledge application (Lu et al., 2025; Yu, 2023). However, PBL should not be assumed to improve scientific writing automatically. Previous research indicates that outcomes depend on problem quality, facilitation, and scaffolding, and that writing-oriented applications may create difficulties when students lack prior knowledge or sufficient guidance (Ghufron, 2018). Therefore, PBL's contribution within the proposed framework is not simply to make writing activities problem-based, but to organize the inquiry and reasoning processes that lead to evidence-based writing while providing explicit writing scaffolding.

The need for STEAM integration reflects the interdisciplinary nature of contemporary scientific writing. Producing a scientific article requires students to understand disciplinary concepts, use digital tools to locate and manage information, apply systematic or design-oriented reasoning, communicate ideas creatively, and interpret quantitative or qualitative evidence. Within the proposed instructional model, science supports conceptual and empirical accuracy, technology facilitates information management and digital writing, engineering or design thinking structures the iterative development of a written product, arts strengthen rhetorical clarity and creative communication, and mathematics supports data interpretation and evidence-based claims. Reviews of STEAM education suggest that interdisciplinary integration can promote creativity, communication, collaboration, and higher-order thinking (Aguilera & Ortiz-Revilla, 2021; Alkhabra et al., 2023; Filipe et al., 2024; Kholid, 2026). However, these findings have predominantly emerged from science, engineering, and school-based contexts rather than from university academic-writing courses. Recent studies illustrate this pattern, including technology-supported STEAM applications for science literacy in elementary education (Rosidah et al., 2025) and problem-solving in disciplinary learning (Nindiasari et al., 2024). Research on STEAM in higher education also shows considerable variation in how integration is conceptualized and implemented, indicating that STEAM principles cannot be automatically transferred to scientific writing (Carter et al., 2021). Therefore, this study contributes by adapting STEAM's interdisciplinary reasoning processes to academic writing, rather than simply attaching STEAM terminology to conventional writing activities.

The strong demand for Augmented Intelligence support reflects the iterative nature of scientific writing and students' need for accessible feedback throughout the process. Unlike generative AI that can directly produce text, Augmented Intelligence positions AI as cognitive support that extends human reasoning while leaving interpretation, verification, and authorship under the student's control. In instructional materials, this support can include guided brainstorming, topic refinement, article-structure checks, rubric-based feedback, coherence evaluation, and prompts for self-revision. Systematic evidence indicates that AI-generated feedback can provide timely, personalized support and encourage repeated revision, particularly when students are taught to evaluate and use the feedback critically (Urzúa et al., 2025). Nevertheless, previous studies also warn that AI outputs can be inaccurate, generic, biased, or disconnected from assignment criteria. Overreliance on generated text may reduce students' engagement in reasoning and create authorship and academic-integrity issues (Kasneci et al., 2023). These contrasting findings explain why the proposed model adopts Augmented Intelligence rather than unrestricted generative AI use: AI assistance should be embedded within lecturer-designed tasks, transparent ethical rules, evaluation rubrics, and student verification procedures.

The high demand for structured instructional materials indicates that students' difficulties in scientific article writing are primarily procedural, cognitive, and iterative rather than limited to understanding theoretical concepts (Fahriany & Wahyunengsih, 2025; Hakim & Abidin, 2024). This interpretation is also supported by needs-analysis research on scientific-writing instruction, which identified the need for web-based teaching materials to support students' writing development (Susanti et al., 2025). Students need instructional support that transforms an abstract writing assignment into a sequence of manageable activities, beginning with identifying a researchable problem and continuing through evidence selection, argument construction, drafting, feedback, and revision. This finding aligns with the process-oriented view of academic writing, which treats writing as a recursive activity requiring planning, composing, evaluating, and revising rather than the production of a single final text. Consequently, instructional materials should function as cognitive scaffolding that connects each stage of writing with examples, gradual exercises, evaluation criteria, and revision guidance (Wartono et al., 2019). This emphasis is consistent with needs-analysis research highlighting the importance of developing digital teaching materials to support students' broader 21st-century learning skills (Putri, 2023; Sustiningsih et al., 2021).

Integrating PBL, STEAM, and Augmented Intelligence can provide a more coherent scientific-writing environment than using each component in isolation because the three approaches address different but complementary learning needs. The growing research attention to technology-supported PBL also indicates increasing interest in combining problem-based inquiry with intelligent or digital technologies. However, the specific application to scientific article writing remains underdeveloped (Kurdiati & Nurohman, 2026). PBL provides the instructional syntax for

identifying and investigating authentic problems, but it does not independently guarantee interdisciplinary idea development or continuous individualized feedback. STEAM broadens students' perspectives and supports creative, technological, and data-based communication, but it does not by itself provide a complete sequence for composing a scientific article. Augmented Intelligence offers rapid scaffolding and feedback, but without a pedagogical framework it may encourage superficial revision or dependence on automated outputs. Their integration therefore creates a complementary mechanism: PBL determines the problem-solving pathway, STEAM enriches the content and forms of reasoning used within that pathway, and Augmented Intelligence supports reflection and revision at critical stages. This theoretical complementarity explains why students expressed a high need for an integrated model rather than for a single instructional strategy.

Based on this synthesis, the proposed instructional model should include problem orientation, STEAM-based interdisciplinary exploration, topic formulation, literature and evidence analysis, argument construction, scientific article drafting, Aul-assisted formative feedback, peer discussion, verification of AI outputs, structured revision, and final article presentation. The instructional materials should translate these stages into an interactive e-module supported by annotated article examples, gradual writing exercises, evaluation rubrics, revision checklists, LMS activities, and printed reference materials (Hafid et al., 2022). The main contribution of the needs analysis is therefore not only identifying students' preferences, but also formulating empirically grounded design specifications that connect PBL, STEAM, and Augmented Intelligence within one scientific-writing instructional system. However, because this study was limited to needs analysis, the proposed integration should be understood as a theoretically and empirically justified design direction rather than as evidence of effectiveness. Subsequent validation and experimental testing must examine its effects on writing quality, critical thinking, creativity, and academic integrity.

LIMITATIONS

This study has several limitations that affect how its findings should be interpreted. First, purposive sampling means the 281 respondents cannot be considered statistically representative of university students beyond the participating programmes and institutional context. The findings should therefore be interpreted as a context-specific needs profile rather than as population-level estimates. Second, the study relied on self-report questionnaire data, which capture students' perceptions, experiences, and expectations but do not directly measure their actual scientific-writing competence. The reported high level of need should consequently not be interpreted as direct evidence of writing performance or as evidence of the causes of students' difficulties. Third, the questionnaire was multidimensional and produced low overall Cronbach's Alpha coefficients, indicating that the present reliability evidence is insufficient to support treating the questionnaire as a single internally consistent scale. Further research should refine the items and examine reliability and construct validity at the dimension level. Fourth, because this study represents only the needs-analysis stage of instructional development, the proposed PBL-STEAM-Aul framework and materials should not be interpreted as validated or effective interventions. The findings provide preliminary design specifications, but subsequent development and empirical testing must establish feasibility, validity, usability, and effects on scientific-writing performance. Finally, students' needs for AI-supported learning may change as intelligent technologies and institutional policies evolve; periodic reassessment will therefore be necessary.

The most critical next step is to develop and validate the PBL-STEAM-Aul instructional model and its supporting materials based on the design specifications identified in this study. Subsequent research should first establish content validity, construct validity, usability, and feasibility of the model and materials, followed by empirical testing using direct measures of scientific-writing performance. Such research would determine whether the needs identified in the present study translate into measurable improvements in students' writing quality and learning processes.

CONCLUSION

This study identified a high perceived need among 281 university students from 12 study programmes for structured support in scientific article writing. The perceived need for the PBL-STEAM-Aul instructional model was high ($M = 4.033$), as was the need for supporting instructional

materials ($M = 4.054$). Students particularly indicated the importance of systematic writing guidance, gradual practice, complete scientific-article examples, scientific communication practice, and human-centered AI-supported feedback and revision. Students most frequently selected an interactive e-module as the preferred material format.

These findings provide preliminary empirical design specifications for an integrated instructional framework in which PBL organizes problem formulation and inquiry, STEAM supports interdisciplinary reasoning and communication, and Aul provides controlled cognitive and formative support while preserving students' responsibility for evidence evaluation, academic judgment, and authorship. The study's contribution is therefore a needs-based foundation for subsequent instructional development rather than evidence that the proposed framework is already effective. Further research should develop and validate the model and materials, then test their feasibility and effects on students' scientific-writing performance.

AUTHOR CONTRIBUTIONS

DL contributed to the study's conceptualization, development of the research instrument, data collection, data analysis, and preparation of the original manuscript. A contributed to the research methodology, validation of the instructional model framework, interpretation of the findings, and critical revision of the manuscript. AM contributed to developing the PBL–STEAM–Aul conceptual framework, reviewing instruments, interpreting data, and editing the manuscript. BK contributed to the theoretical analysis of scientific article writing, reviewing the instructional-material components, and improving the discussion section. BS contributed to research supervision, methodological evaluation, validation of the research findings, and final approval of the manuscript. All authors reviewed, revised, and approved the final version of the manuscript and agreed to be accountable for the accuracy and integrity of the work.

ACKNOWLEDGMENT

The authors express sincere appreciation to Universitas Lampung for providing academic support during the implementation of this study. The authors also extend their gratitude to the lecturers and academic staff from the participating study programs who helped coordinate the data-collection process. Special thanks go to the 281 university students who voluntarily participated in the needs analysis and provided valuable information about their experiences, difficulties, and expectations in learning to write scientific articles. Their responses contributed significantly to formulating the initial specifications of the PBL–STEAM–Aul instructional model and its supporting instructional materials. The authors are also grateful to the experts who reviewed the research instrument and provided constructive comments to improve its relevance, clarity, and alignment with the research objectives.

REFERENCES

- Aguilera, D., & Ortiz-Revilla, J. (2021). STEM vs. STEAM education and student creativity: A systematic literature review. *Education Sciences*, 11, 331. <https://doi.org/10.3390/educsci11070331>
- Alkhabra, Y. A., Ibrahim, U. M., & Alkhabra, S. A. (2023). Augmented reality technology in enhancing learning retention and critical thinking according to STEAM program. *Humanities and Social Sciences Communications*, 10(1), 174. <https://doi.org/10.1057/s41599-023-01650-w>
- Amelia, R. (2023). Need analysis of integrated science digital teaching materials with blended learning models in the new normal era for PGMI students throughout East Java. *Al Ibtida: Jurnal Pendidikan Guru MI*, 10(1), 29–41. <https://doi.org/10.24235/al.ibtida.snj.v10i1.12021>
- Ayanwale, M. A., & Omeh, C. B. (2026). AI-supported problem-based learning for enhancing computational thinking skills in STEM education. *Computers in Human Behavior: Artificial Humans*, 100263. <https://doi.org/10.1016/j.chbah.2026.100263>
- Carter, C. E., Barnett, H., Burns, K., Cohen, N., Durall, E., Lordick, D., Nack, F., Newman, A., & Ussher, S. (2021). Defining STEAM approaches for higher education. *European Journal of STEM Education*, 6(1), 1–16. <https://doi.org/10.20897/ejsteme/11354>
- Diani, R., Yuberti, & Syarlisjiswan, M. R. (2018). Web-enhanced course based on problem-based

- learning (PBL): Development of interactive learning media for Basic Physics II. *Jurnal Ilmiah Pendidikan Fisika Al-Biruni*, 7(1), 105–116. <https://doi.org/10.24042/jipfalbiruni.v7i1.2849>
- Fahriany, F., & Wahyunengsih, W. (2025). English reading in Indonesian Islamic boarding schools: Needs and materials. *Nazhruna: Jurnal Pendidikan Islam*, 8(1), 246–264. <https://doi.org/10.31538/nzh.v8i1.64>
- Fang, J.-W., Guo, X.-G., Meng, X.-P., Hwang, G.-J., & Tu, Y.-F. (2026). Realization of parasocial interaction theory in STEAM education with an AI pedagogical agent: Insights from learning performance, collaboration tendency, and problem-solving tendency. *Interactive Learning Environments*, 34(2), 694–717. <https://doi.org/10.1080/10494820.2025.2508326>
- Filipe, J., Baptista, M., & Conceição, T. (2024). Integrated STEAM education for students' creativity development. *Education Sciences*, 14(6), 676. <https://doi.org/10.3390/educsci14060676>
- Ghufron, M. A., & Ermawati, S. (2018). The strengths and weaknesses of cooperative learning and problem-based learning in EFL writing class: Teachers' and students' perspectives. *International Journal of Instruction*, 11(4), 657–672. <https://doi.org/10.12973/iji.2018.11441a>
- Hafid, H., Barnoto, B., Shonhadji, & Abuhsin, J. (2022). Manajemen pembelajaran kelas digital berbasis Google Workspace for education. *Kharisma: Jurnal Administrasi Dan Manajemen Pendidikan*, 1(1), 48–58. <https://doi.org/10.59373/kharisma.v1i1.5>
- Hakim, M. N., & Abidin, A. A. (2024). Platform merdeka mengajar: Integrasi teknologi dalam pendidikan vokasi dan pengembangan guru. *Kharisma: Jurnal Administrasi Dan Manajemen Pendidikan*, 3(1), 68–82. <https://doi.org/10.59373/kharisma.v3i1.47>
- Hosna, R., Idawati, K., Hanifudin, Mahsun, A., Budiarti, E. M., Ilahiyah, I. I., & Mustaji. (2026). Development of artificial intelligence-based Akidah Akhlak teaching materials for Islamic senior high schools in Indonesia. *Nazhruna: Jurnal Pendidikan Islam*, 9(1), 207–226. <https://doi.org/10.31538/nzh.v9i1.355>
- How, M.-L., & Hung, W. L. D. (2019). Educing AI-thinking in science, technology, engineering, arts, and mathematics (STEAM) education. *Education Sciences*, 9(3), 184. <https://doi.org/10.3390/educsci9030184>
- Jaramillo-Fierro, X., Guaya, D., Meneses, M. A., & Valarezo, E. (2026). Integrating generative Artificial Intelligence and Augmented Reality within a structured project-based learning framework for unit operations education. *Sustainability*, 18(5), 2317. <https://doi.org/10.3390/su18052317>
- Jesionkowska, J., Wild, F., & Deval, Y. (2020). Active learning augmented reality for STEAM education—A case study. *Education Sciences*, 10(8), 198. <https://doi.org/10.3390/educsci10080198>
- Kasneci, E., Sessler, K., Küchemann, S., Bannert, M., Dementieva, D., Fischer, F., Gasser, U., Groh, G., Günemann, S., Hüllermeier, E., Krusche, S., Kutyniok, G., Michaeli, T., Nerdel, C., Pfeiffer, F., Poquet, O., Sailer, M., Schmidt, A., Seidel, T., ... Kasneci, G. (2023). ChatGPT for good? On opportunities and challenges of large language models for education. *Learning and Individual Differences*, 103, 102274. <https://doi.org/10.1016/j.lindif.2023.102274>
- Kholid, I. (2026). Technology-enhanced co-creative pedagogies: Transforming collaboration, critical thinking, and innovation in STEAM education. *International Journal of Technology in Education*, 9(2), 379–401. <https://doi.org/10.46328/ijte.5182>
- Kuo, H.-C. (2025). Transforming tomorrow: A practical synthesis of STEAM and PBL for empowering students' creative thinking: HC kuo. *International Journal of Science and Mathematics Education*, 23(6), 2061–2087. <https://doi.org/10.1007/s10763-024-10511-0>
- Kurdiati, L. A., & Nurohman, S. (2026). Understanding the research evolution, knowledge structure, and trends of augmented reality-supported problem-based learning: A bibliometric perspective. *Journal of Mathematics Science and Computer Education*, 6(1), 13–33. <https://doi.org/10.20527/jmscedu.v6i1.18274>
- Li, P.-H., Lee, H.-Y., Lin, C.-J., Wang, W.-S., & Huang, Y.-M. (2025). InquiryGPT: Augmenting ChatGPT for enhancing inquiry-based learning in STEM education. *Journal of Educational Computing Research*, 62(8), 1937–1966. <https://doi.org/10.1177/07356331241289824>
- Lu, L., Mustakim, S. S., & Muhamad, M. M. (2025). A meta-analysis of the effectiveness of problem-based learning on critical thinking. *European Journal of Educational Research*, 14(3), 789–804. <https://doi.org/10.12973/eu-jer.14.3.789>

- Mulianah, B., Usman, F., Rokhman, M., Fatikh, M. A., Andriana, I., Nabila, M. A., & Kholis, M. M. N. (2025). The role and threats of using ChatGPT in higher education: Balancing pedagogical potential and ethical risks. *Nazhruna: Jurnal Pendidikan Islam*, 8(3), 550–560. <https://doi.org/10.31538/nzh.v8i3.218>
- Nindiasari, H., Pranata, M. F., Sukirwan, S., Sugiman, S., Fathurrohman, M., Ruhimat, A., & Yuhana, Y. (2024). The use of augmented reality to improve students' geometry concept problem-solving skills through the STEAM approach. *Infinity Journal*, 13(1), 119–138. <https://doi.org/10.22460/infinity.v13i1.p119-138>
- Putri, R. M. (2023). Need analysis of developing digital teaching materials to improve 21st century skills. *Jurnal IPA & Pembelajaran IPA*. <https://doi.org/10.24815/jipi.v7i2.29797>
- Ratnakaram, S., Alhejair, A., & Alawi, S. H. (2025). Charting the impact of AI-augmented problem-based learning in higher education. *Empowering Learners With AI: Strategies, Ethics, and Frameworks: Strategies, Ethics, and Frameworks*, 39. <https://doi.org/10.4018/979-8-3373-7386-7.ch002>
- Rosidah, C. T., Azmy, B., Irianto, A., Rosi, A. M., & Islami, S. A. (2025). Integrating augmented reality and deep learning in an interactive STEAM-based digital storybook to enhance elementary school students' science literacy. *Journal of Cultural Analysis and Social Change*, 1620–1628. <https://doi.org/10.64753/jcasc.v10i3.2636>
- Stevi, S., & Haryanto, H. (2020). Need analysis of audio-visual media development to teach science materials for young learners. *Journal of Educational Technology and Online Learning*, 3(2), 152–167. <https://doi.org/10.31681/jetol.672104>
- Susanti, E., Hikmat, A., & Tarmini, W. (2025). Needs analysis fo the development of web-based teaching materials in scientific writing skills instruction for eleventh-grade vocational high school students. *BAHA STRA*, 45(2), 222–231. <https://doi.org/10.26555/bs.v45i2.1407>
- Sustiningsih, Utaminingsih, S., & Santoso. (2021). Development of science teaching materials based on STEM: A needs analysis. *Journal of Physics: Conference Series*, 1823(1), 12081. <https://doi.org/10.1088/1742-6596/1823/1/012081>
- Syukur, F., Maghfurin, A., Marhamah, U., & Jehwae, P. (2024). Integration of artificial intelligence in Islamic higher education: Comparative responses between Indonesia and Thailand. *Nazhruna: Jurnal Pendidikan Islam*, 7(3), 531–553. <https://doi.org/10.31538/nzh.v7i3.13>
- Tian, N. (2025). AI-enhanced PBL: Integrating artificial intelligence into project-based learning for youth STEM education. *Proceedings of the 2025 2nd International Conference on Artificial Intelligence and Future Education*, 455–460. <https://doi.org/10.1145/3785987.3786062>
- Urzúa, C. A. C., Ranjan, R., Saavedra, E. E. M., Badilla-Quintana, M. G., Lepe-Martínez, N., & Philominraj, A. (2025). Effects of AI-assisted feedback via generative chat on academic writing in higher education students: A systematic review of the literature. *Education Sciences*, 15(10), 1396. <https://doi.org/10.3390/educsci15101396>
- Utaminingsih, S. (2021). Development of science teaching materials based on STEM: A needs analysis. *Journal of Physics: Conference Series*, 1823(1). <https://doi.org/10.1088/1742-6596/1823/1/012081>
- Wartono, W., Alfroni, Y. F., Batlolona, J. R., & Mahapoonyanont, N. (2019). Inquiry-scaffolding learning model: Its effect on critical thinking skills and conceptual understanding. *Jurnal Ilmiah Pendidikan Fisika Al-Biruni*, 8(2), 245–255. <https://doi.org/10.24042/jipfalbiruni.v8i2.4214>
- Yu, L., & Zin, Z. M. (2023). The critical thinking-oriented adaptations of problem-based learning models: A systematic review. *Frontiers in Education*, 8, 1139987. <https://doi.org/10.3389/feduc.2023.1139987>
- Yuliyati, Y., Budiyanto, B., & Purbaningrum, E. (2018). A needs analysis of instructional materials on methodology of research based on scientific publications for special education master program. *2nd International Conference on Education Innovation (ICEI 2018)*, 534–537. <https://doi.org/10.2991/icei-18.2018.115>
- Yurnetti, Asrizal, & Murtiani. (2020). Need analysis to develop science learning material based on thematic teaching by integrating the new literacy. *Journal of Physics: Conference Series*, 1481(1), 12122. <https://doi.org/10.1088/1742-6596/1481/1/012122>